# POWER

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THE FOOT OF THE LADDER

# Westinghouse Marine Equipment

*SYNOPSIS—Description of the marine steam turbine, reduction gear, bridge control and auxiliaries as built by the Westinghouse Machine Co. with special reference to the installation on the U. S. collier "Neptune."*

In the application of steam turbines to marine service, certain problems are encountered which are not present in land practice. Among these may be mentioned the desirability of relatively low propeller speeds, whereas it is desirable to run the turbine at high speed to keep down the size and weight and to attain greater economy. This condition led to the development of the Melville-Macalpin reduction gear, which has now passed the experimental stage, and has successfully met the requirements for the transmission of large powers in actual service, the most notable installation being that of the U. S. collier "Neptune."

The results of the trials of the original equipment of this vessel, while demonstrating the adaptability of reduction gears to marine service showed the necessity of modifications of the turbine and reduction gear. One of the important points brought out by the trials was that the revolutions of the propeller were too high, the original revolutions at 14 knots being 135 and those of the turbine 1220. It was decided, therefore, to replace the propelling machinery, one of the changes being a decrease in propeller speed to 110 r.p.m. and an increase in turbine speed to 1910 r.p.m. The following description applies to the remodeled arrangement and also represents what the Westinghouse Machine Co. has developed as a complete line of equipment for marine service, including the turbine, condensers and auxiliaries, reduction gear and dynamometer, and bridge control by which the turbine is under the complete control of the navigating officer.

## Turbine

This is a combination impulse and reaction type, the high-pressure elements of both the ahead and astern turbines consisting of impulse wheels. The substitution of a high-pressure impulse wheel for reaction blading in marine turbines has two important advantages: First, it has a greater stopping torque, and, second, it permits nozzle control. Furthermore, it materially shortens the turbine and permits both the ahead and the astern turbines to be contained in one casing, thus eliminating cross-connections.

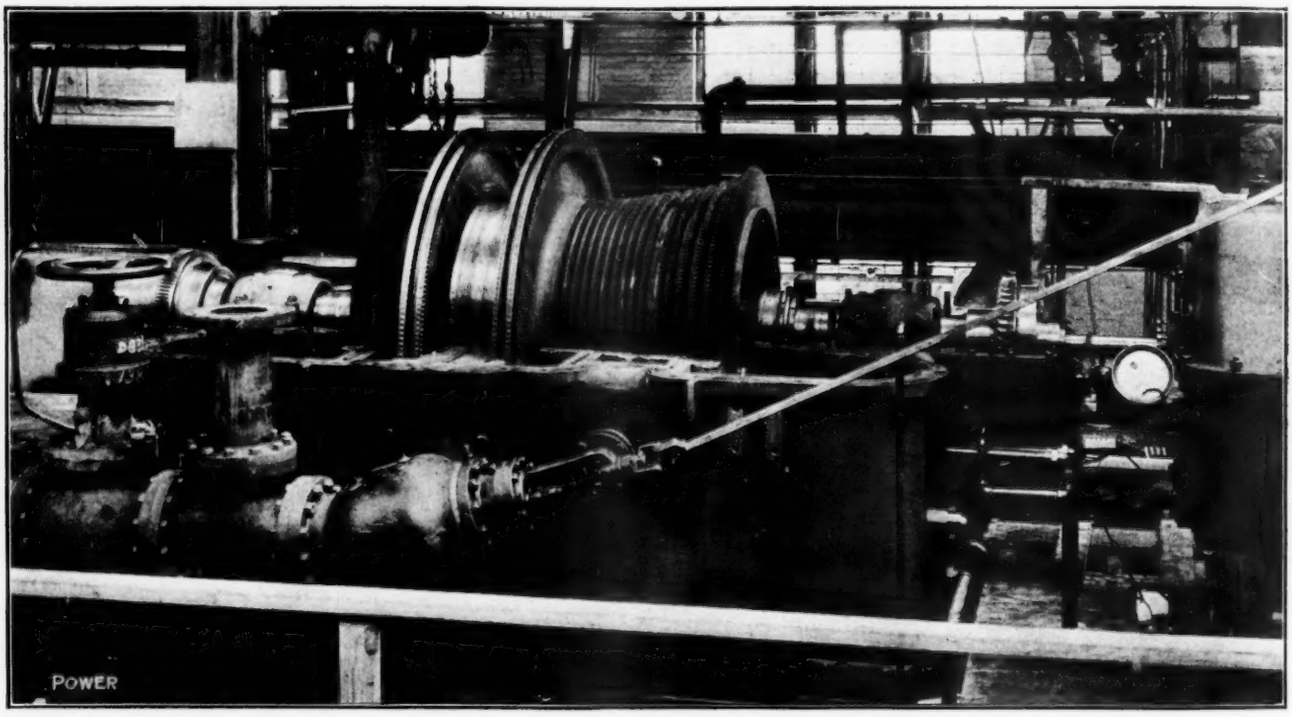



Fig. 1. Turbine with Casing and Blade Rings Removed

Although the impulse wheel is not as efficient as reaction blading, it is possible to so design an impulse wheel with two rows of blades that its efficiency will not fall off seriously when the steam velocity is only 2 to 2½ times the blade speed, and will remain nearly constant until the velocity of the steam reaches 4 to 4½ times the blade speed. Therefore, by the use of nozzle control the efficiency of the high-pressure element may be kept fairly constant over a considerable range of power and speed.

Fig. 1 shows the turbine with the stationary blade rings removed, and Fig. 2 is a section through the turbine. It will be noted that the spindle is in three parts, bolted together. The first section carries the astern impulse wheel and reaction drum, the middle section the ahead impulse wheel and part of the ahead reaction drum, and the third section the remaining part of the reaction drum. As the effective mean diameter of the ahead and astern reaction sections are the same, a single dummy located between the two impulse wheels serves for both the ahead

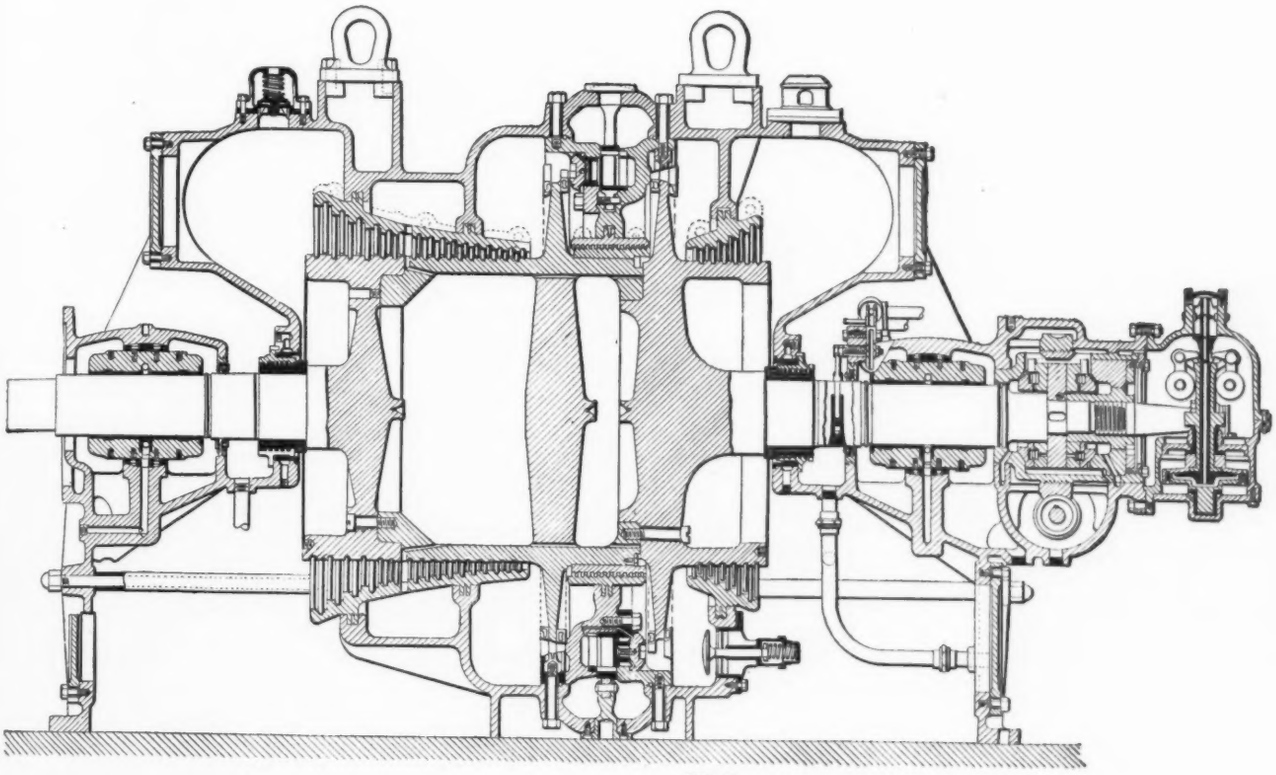


FIG. 2.

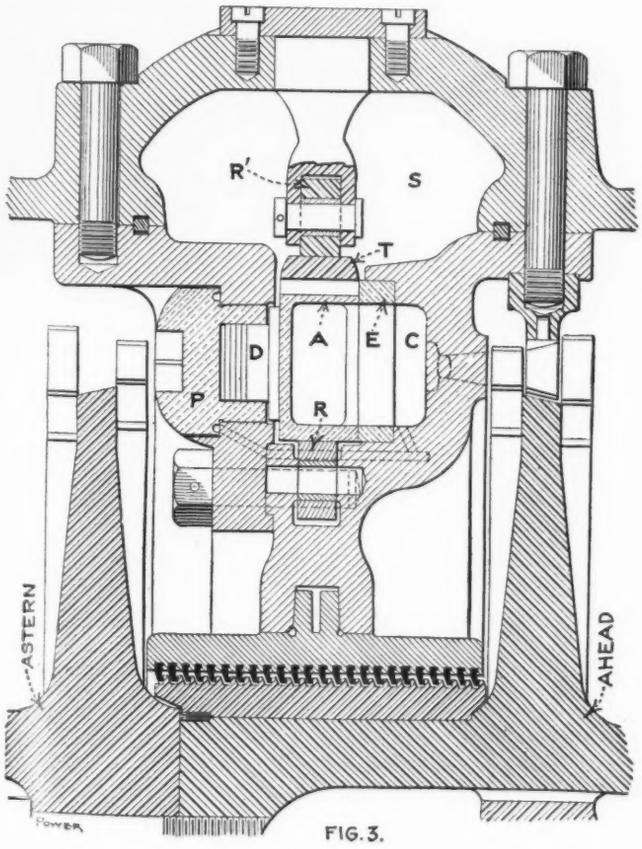



FIG. 3.

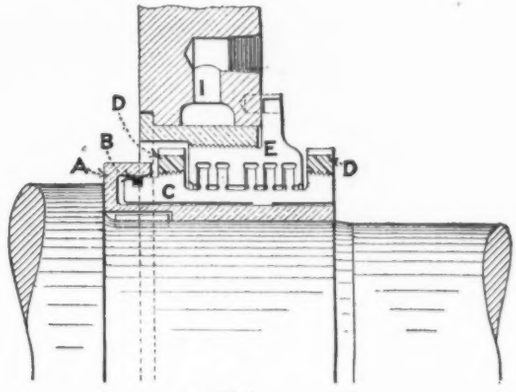



FIG. 4.

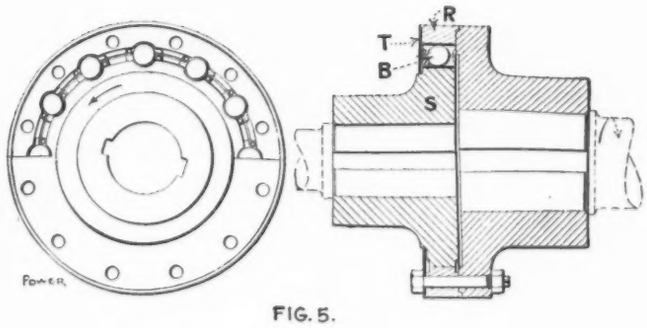



FIG. 5.

SECTION AND DETAILS OF WESTINGHOUSE MARINE TURBINE

Fig. 2. **Longitudinal section through turbine.** **Fig. 3. Nozzle valve and nozzles.** **Fig. 4. Turbine glands.** **Fig. 5. Flexible coupling.**

and the astern reaction sections. Any slight unbalanced end thrust is taken up by a Kingsbury thrust bearing.

Referring to Fig. 2, the valve connecting the astern impulse-wheel chamber with the condenser is provided to permit the escape of any steam leaking past the dummy when running ahead, without the necessity of its passing through the astern reaction blading and thus causing additional lost work. This bypass valve is operated automatically by a piston resisted by the spring which normally holds the valve open, as shown, but as soon as the steam is admitted to the first astern nozzle the pressure back of the piston brings the valve to its seat.

In Fig. 3 is shown the nozzle valve and nozzles. The valve *A* is of monel metal with a cast-iron seat *E*, the balancing pistons *D* and caps *P* being of bronze. The nozzle valve *A* is moved by a rack engaging with gear teeth in the ring *T*, and rollers *R* and *R'* permit easy movement of the valve. The main steam supply for the ahead impulse wheel opens into the space *S* in the lower half of the turbine cylinder and that for the astern wheel into a similar space in the upper half.

One of the ahead nozzle blocks and the sliding valve are shown partly assembled in Fig. 6, also four of the balance pistons in place. The turbine glands are a modified type of labyrinth packing, as shown in Fig. 4, consisting of a brass sleeve *A* on the shaft in which fits a snap ring *B* packing the sleeve *C*, held by the rings *D*, and which rotates with the shaft. End movement of the sleeve *C* relative to the shaft is permitted so that the collars which fit into the bushing *E* with a few thousandths clearance will not bind nor press heavily against *E* when the spindle moves endwise from expansion. Steam for sealing and lubricating the labyrinth is supplied through the inlet *I*.

The stationary reaction blades are held in cast-steel rings doweled to the turbine cylinder, Fig. 7 showing the method of attaching the large reaction blades.

In order to permit the gear pinion to float longitudinally without imposing any end thrust on the teeth of the pinion or gear, a special flexible coupling (Fig. 5) is used. This coupling consists simply of two flanged collars, one on the turbine and one on the pinion drive shaft, and a ring *R* bolted to the part of the coupling on the turbine shaft. There is a slight clearance between the ring *R* and the hub *S*, and the driving force is transmitted through the ring to the hub by means of steel balls *B* inserted in holes drilled partly in the ring and partly in the hub. A retaining ring *T* prevents the balls from coming out.

### Reduction Gear

Although the principle of the Melville-Macalpin gear and its later development by George Westinghouse have been mentioned in these columns, a brief review may be in order at this time. Referring to Fig. 8, *AA* is a double-helical pinion, *BB* the driven gear and *CC* the frame carrying the pinion-shaft bearings; *DDD* are three pistons resting on suitable supports. Oil under pressure is introduced through the passage communicating with each of the pistons and causes the pinion frame *C* to float. Inasmuch as the three supporting cylinders are in communication with one another, the pinion frame is free to align itself in such a way as to bring about an even distribution of tooth pressure across the entire working face of the gear. To provide for reversed rotation, and, consequently a reversed thrust on the pinion frame, a second set of cylinders and pistons is placed on the opposite side, as may be seen in Fig. 9, which represents a cross-section through the floating pinion frame at the middle bearing. Low-pressure oil is introduced into the upper end of the central passage and through *J*, which communicates with the three shaft bearings. Assuming that the pinion is rotating in a clockwise direction, the reaction between it and the gear will cause the floating frame *L* to tilt slightly to the right, which brings the outlet to passage *F'* against the sleeve valve *K'* and seals the former. The spring in the valve *K'* provides easy contact and does away with any hammering.

Each bearing will draw oil from *J* and discharge through the opening on the right, past a ball check valve into the chamber *H'H'*, thence into the cylinders containing the supporting pistons *D'*. Since the outlet from *F'* is sealed by the valve *K'*, the oil pressure will build up, due to the pumping action of the shaft, until it just balances the side thrust of the floating frame. The instant this pressure is exceeded, the pinion frame is forced slightly to the left, causing the upper end of *F'* to become unsealed and allowing the surplus oil to escape into the gear case from whence it is returned to passage *G*. In this way the valve *K'* throttles the discharge from *F'* sufficiently to maintain the pressure constant behind the pistons *D'*. With the reverse direction of rotation the action is the same, the valve *K* and passage *F* coming into use.

The pressure of the oil is proportional to the force exerted at the pitch line of the gears. This force multiplied by the pitch-line speed in feet per minute divided by 33,000 gives the horsepower that is being transmitted. Therefore, by connecting a continuous-speed recorder and a recording pressure gage, a continuous dynamometer record may be had.

### Bridge Control

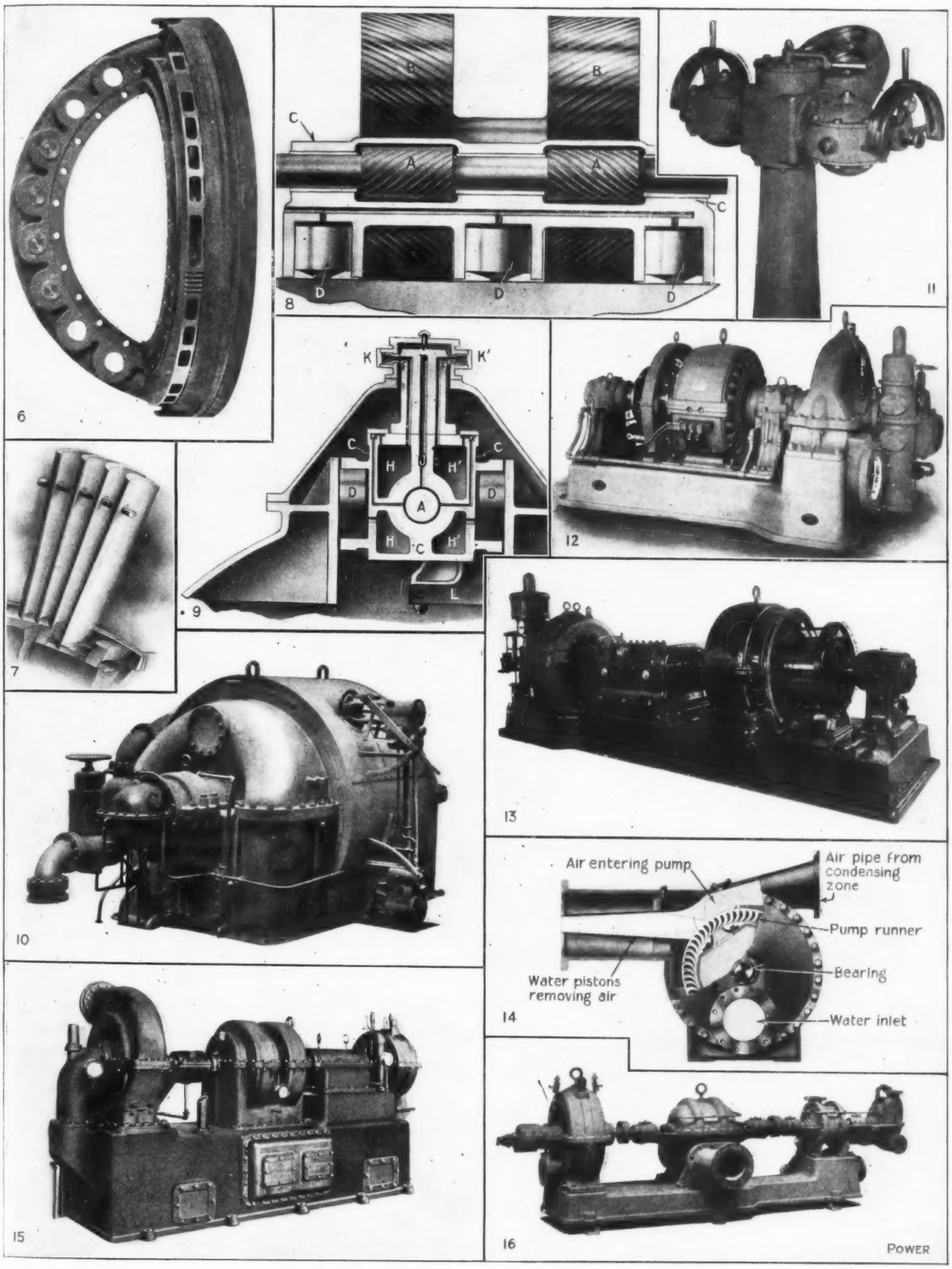
A novel feature of the "Neptune's" equipment is the bridge-control mechanism which places the propelling machinery directly under the control of the navigating officer and does away with the necessity of using the engine-room telegraph. A change can be made to the telegraph and engine-room control in a few seconds if necessary. In the preliminary trials this control was found to give entire satisfaction. Fig. 10 shows the port turbine of the "Neptune" with the oil relays, the governor being on the other end; and Fig. 11 the bridge-control stand, which is so arranged that both turbines may be controlled independently or together.

### Auxiliaries

The full line of marine auxiliaries comprises generating sets, both direct and alternating current; condensing equipment, including surface condensers, air pumps, condensate pumps and circulating pumps; high- and low-pressure centrifugal pumps and centrifugal fans. The principal characteristic of these is the use of a simple rotating element instead of many reciprocating parts.

### Generating Sets

Direct-current generating sets with direct drive are built in sizes of from 1 to 150 kw. and with gear drive in sizes of from 50 to 500 kw., the problem of drive in




TURBINE AND REDUCTION-GEAR DETAILS AND AUXILIARIES

Fig. 6. Nozzle block. Fig. 7. Large reaction blading. Figs. 8 and 9. Reduction gear showing floating frame. Fig. 10. Port turbine with oil relays. Fig. 11. Bridge control stand. Fig. 12. 100-kw. direct-current turbo-generator. Fig. 13. 300-kw. direct-current generator with geared turbine drive. Fig. 14. Leblanc pump. Fig. 15. Combined air and circulating pumps with geared turbine drive. Fig. 16. Combined air, condensate and circulating pumps with direct turbine drive.

the larger units being in many respects similar to that of driving a propeller. These units are furnished either condensing or noncondensing up to 150 kw., and above this, condensing only. The weights of the geared sets range from 15 to 45 lb. per horsepower.

While direct current has heretofore been used almost exclusively in marine practice, several alternating-current installations have been made recently and its further use is anticipated. Owing to the desirability of high speeds with alternating-current generators, direct drive is employed exclusively with these sets. They are also condensing and are furnished in sizes of 100 to 500 kw., 60 cycles and voltages of 125, 220 and 440.

In the small generating sets the bearings are ring lubricated, but in the 25-kw. size and above, forced lubrication is employed.

### Condensing Equipment

The Westinghouse condensing plant, as shown in Fig. 17, consists of a surface condenser, a Leblanc air pump and a centrifugal circulating pump. These are furnished separately or combined on a shaft. Fig. 15 shows combined air, and circulating pumps with geared drive, and Fig. 16 combined air, condensate and circulating pumps with direct turbine drive.

The air pump is of the Leblanc type, which uses fresh water in a closed circuit, and is made in capacities from 800 to 25,000 sq.ft. of cooling surface. For the benefit of those not familiar with this type of pump, its operation may be explained briefly as follows: Referring to Fig. 14, a continuous series of rapidly moving layers of water are projected into the air chamber, condensing the vapor present and cooling and concentrating the air

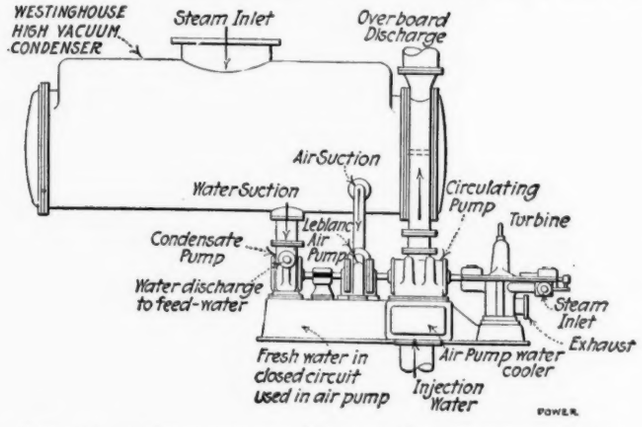



Fig. 17. Westinghouse Marine Condensing Plant

which is imprisoned between the pistons or vanes and carried out through the discharge nozzle, during which process it is compressed to atmospheric pressure. The water pistons have no clearances and there are no reverses; consequently no losses due to these causes.

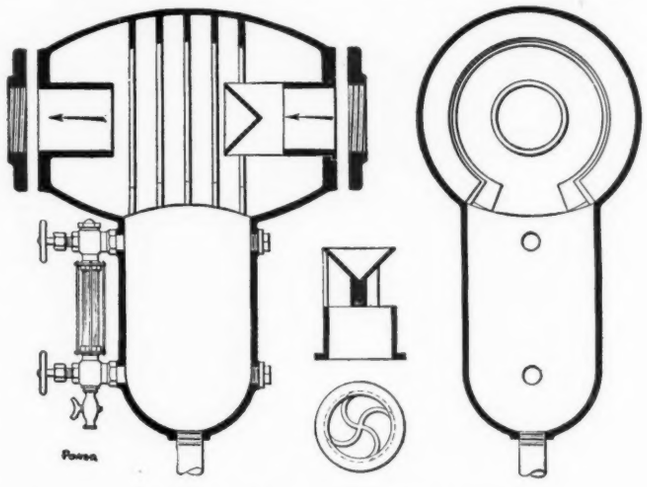
The condensate pump is a single-stage, double-inlet runner, horizontal type, although for naval use a special vertical type with single-inlet runner is supplied.

Either a single or double runner, double-inlet centrifugal pump is used for circulating, in capacities of from 400 to 40,000 gal. per min. against heads of from 15 to 60 ft. and at speeds of from 225 to 2500 r.p.m. They weigh from 800 to 27,000 lb. complete.

In the type of turbine used for driving the auxiliaries there is a single-disk rotor with a single row of blades. In the noncondensing type the steam expands once and passes through the blades twice, whereas in the condensing type it expands twice and passes through the blades four times. By redirecting the steam through the same row of blades several times, its energy is fully utilized by a simple construction.

## Caps Oil Separator

The separator shown in section in the accompanying drawings has been recently designed by John E. Caps, of the Cartwright-Caps Co, Chicago It is provided with



Section of Caps Oil Separator

a cone-shaped member on the inlet side whose vertex lies toward the source of the exhaust steam. On the convex surface of the cone are mounted four curved blades to give a whirling motion to the steam and facilitate the separating process. Impinging against the blades and the surface of the cone, the steam is deflected against the inner surface of the separator wall where it encounters a series of ribs and eventually passes through the outlet at the opposite end of the separator. The condensation and the oil drain into the receiving chamber below the body of the separator and are drained off through the bottom connection. In the sectional and detail views, the construction of the separator is clearly shown.

## Concrete Mixtures

A good way to determine the amount of sand and cement necessary to add to a given grade of crushed stone for foundations, etc., is as follows:

Fill a box or other receptacle of a known size level full of broken stone. Then put in enough sand to fill the voids. This will determine the amount of sand necessary. Next put as much water into the box as will in turn fill the voids which the sand has left. This will indicate the amount of cement required. An additional 5 to 10 per cent. of cement should be used to allow for its not being thoroughly distributed in the mixing process, but it should not be considered as strengthening the concrete.

It will be found that the proportions vary considerably with the different grades of stone and sand used. Therefore, the proportions so often arbitrarily referred to may or may not be the best to use in a given case.

# Depreciation and How It Is Applied

By Charles H. Bromley

*SYNOPSIS—This article treats in a simple way the essentials of depreciation as a fixed charge in power-plant practice.*

## Rate of Depreciation

To depreciate a thing is to lower its value—make it worth less at the end of a given time than it was when new. In power-plant practice it is a charge made against the deterioration, the "wearingoutness," either slow or fast, of the plant or any particular apparatus in it. Depreciation infers a money value, a state of physical condition. The rate of depreciation or deterioration is the amount the plant wears out *yearly*. This rate is based on the assumed useful life of the plant or apparatus and is expressed in per cent. of this period, which is taken as the base, or 100 per cent. Thus, if we assume that a plant will last 25 years, then 25 years is 100 per cent. of the lifetime of the plant, and the rate at which it must wear out yearly will obviously be 4 per cent. If it lasts 40 years, the rate of deterioration will be

$$100 \div 40 = 2.5, \textit{ or } 2.5 \textit{ per cent.}$$

If it lasts 20 years the rate is 5 per cent.; 15 years, 6.67 per cent.; 10 years, 10 per cent., etc.

The depreciation *charge* is based on and equal to the life deterioration rate, but it represents an amount of money which is the same percentage of the original investment, 100 per cent., as the deterioration rate is a percentage of the useful lifetime of the plant, 100 per cent. The depreciation charge is the amount of money which, if set aside each year for the number of years which the plant lasts, would equal the original cost of the plant, or the original investment.

Suppose we install a plant for $50,000 and assume that the plant will last 20 years. It will wear out at the rate of 5 per cent. per year for 20 years, at the end of which time the original plant will have gone. and so will the original investment of $50,000. If this annual charge is put into a fund with which to buy a new plant to replace the one worn out, it is called a sinking fund.

## Interest

So far interest has not been considered in connection with the depreciation charge, but in practice it should be. Experience teaches that apparatus does not wear out uniformly; the rate increases with the age of the apparatus, providing the conditions of its use are unchanged. Work that will wear out a young man slowly will wear out an old man quickly.

When interest is added to the depreciation fund or rate it naturally will be compounded. The amount in the fund set aside at compound interest will increase slowly at first, but year by year it will increase more rapidly. The fund, therefore, increases at a rate which about equals the ever increasing rate of deterioration. In actual business this sum usually is not regularly put aside, invested, and banked at interest, but the bookkeeping department should account for this fund just as though it were invested at current rates of interest.

## Obsolescence

In small, and even in many large manufacturing plants, the depreciation charge covers or includes the decrease in plant value, due to its going out of date or becoming too uneconomical as compared to more modern equipment. The physical value of the equipment may be nearly as good as when new, but its commercial value is less; it has depreciated, because other equipment, more economical and suitable, is available in the market. One could hardly be induced to accept as a gift a 1903 model automobile, even though it had never been used and was in perfect physical condition. It is out of date, obsolete. Power-plant equipment becomes obsolete, and when its value decreases in this way it is either provided for in the depreciation charge or a separate charge, called an obsolescence charge, is made. In small plants this charge is included under depreciation, but in large ones, especially the central stations, it is often made a separate charge.

An example of equipment in good physical condition becoming obsolete is that given by the Seventy-Fourth St. station of the Interborough Rapid Transit Co., New York City, where a number of angle-compound reciprocating engines of 5500 hp. each are to be discarded for three turbines of 30,000 kw. each. Even though these units are to be scrapped it is notable that the overall economy of this station is greater now than when comparatively new.

It should be understood that it is most difficult to tell how long a plant will give useful service, and therefore depreciation rates as usually assigned are really only an approximation. The interest to be added to the depreciation charge is governed by the interest rates current in any particular locality.

Experience teaches that different apparatus in any plant does not depreciate uniformly; some kinds having much shorter lives than others. Then, too, certain parts of a machine may wear out several times before the rest has deteriorated. The practical result is that to avoid great complexity of accounts we should, and usually do, include the whole plant in the depreciation charge.

The main fact for the engineer to remember is that deterioration and depreciation are directly influenced and dependent on the care given the plant. A careless, incompetent man may increase the depreciation rate so much more than when under careful management, that he could be fined for his work, or misapplied work, instead of receiving a salary.

## Relation of Repairs to Depreciation

If we operated a machine for its entire life without spending a cent on it for repairs or replacements, no complication of items would arise to make the depreciation charge confusing. In practice we imitate this condition. For convenience only, we keep the depreciation charge separately and include repair and renewal charges under maintenance, which in most plants is not considered a fixed charge but a variable expense in addition to the cost of attendance. It is best to make a separate charge for supplies instead of adding it to maintenance as is practiced by some engineers.

# Draft Loss through Boilers*

By Osborn Monnett†

*SYNOPSIS—Taking the draft at the stack side of the damper as 100 per cent., relative draft readings at other points through the boiler are given in percentages. The data cover practically all types of stationary boilers on the American market.*

A careful study has been made of installations in commercial operation to determine the draft loss through the average boiler setting as ordinarily installed. The data given are not actual readings, as these may vary widely under different conditions even through the same boiler. Rather, the attempt has been made to indicate the draft relations that can reasonably be expected in the average plant as obtained from a large number of different readings on each type of boiler. A plan has been worked out by which the draft available through the boiler is expressed in percentage of the draft at the stack side of the damper, recognizing the fact that the damper is an integral part of the boiler setting and must be included in studying draft conditions.

These data have proved to be sufficiently accurate to serve as a guide in supervising the plans of at least 1000 boilers a year for the past three years, using Illinois coals on hand-fired grates having an air space of 45 to 55 per cent. and rates of combustion of from 20 to 30 lb. of coal per square foot. The data also apply to mechanical stokers burning from 25 to 40 ft. of coal per square foot of grate, with the capacities in either case ranging from rating to 50 per cent. overload.

Taking the draft at the stack side of the damper as 100 per cent. and the draft available at any given point in the setting as a percentage of it, reduces the problem to a standard basis and simplifies the calculations necessary. In the accompanying illustrations enough types are given to enable the designer to approximate the draft loss through nearly any make of boiler on the American market. With the data on the sketches it is possible to calculate the stack height necessary for a given draft

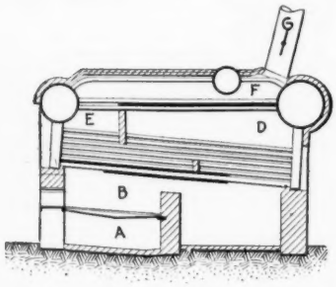



FIG. 1- ATLAS BOILER, HORIZONTAL BAFFLES

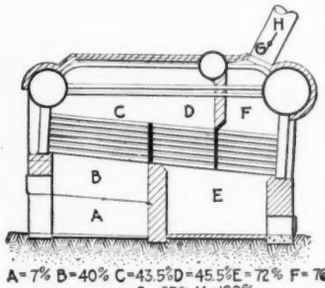



FIG. 2- ATLAS BOILER, VERTICALLY BAFFLED

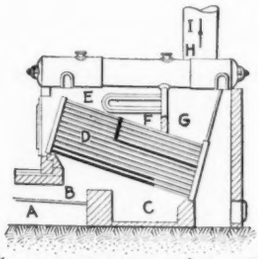



FIG. 3- B&W. BOILER, SEWELL BAFFLE

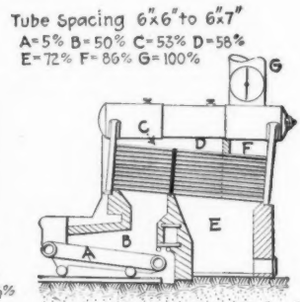



FIG. 4- WATER-TUBE BOILER, THREE PASS VERTICALLY BAFFLED

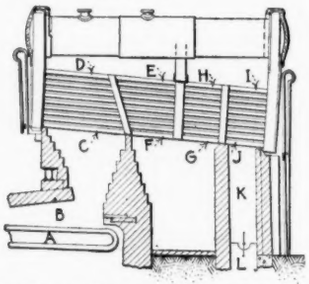



FIG. 5- EDGE MOOR, FOUR PASS BOILER, 18 FT. TUBES

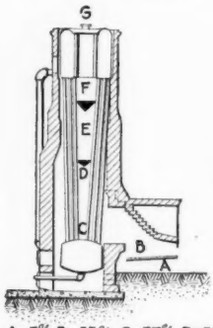



FIG. 6- CAHALL BOILER

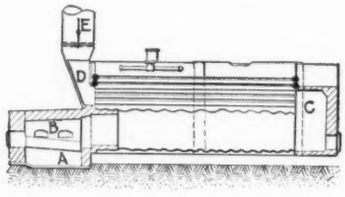



FIG. 7 CONTINENTAL BOILER

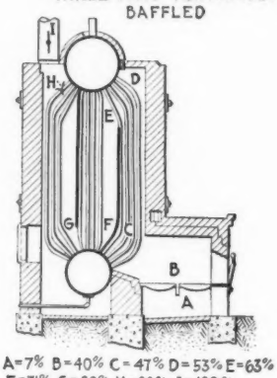



FIG. 8- ERIE CITY VERTICAL BOILER

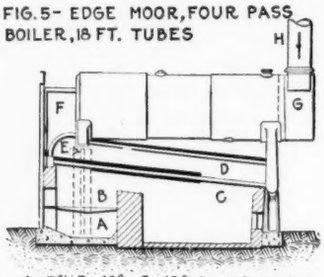



FIG. 9- HAWKES BOILER

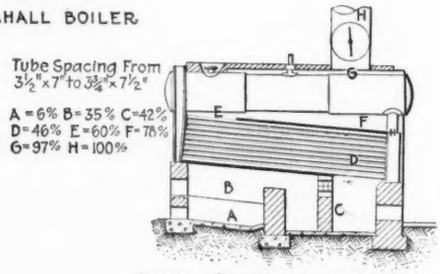
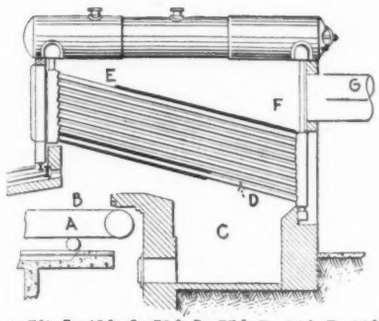



FIG. 10- HORIZONTAL WATER TUBE BOILER

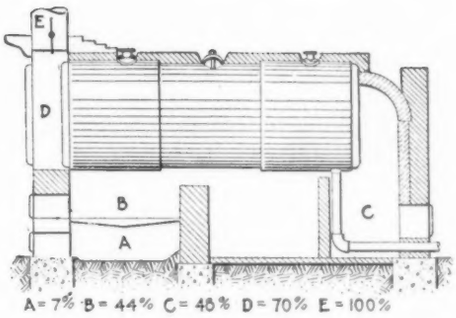
Showing Draft Losses through Ordinary Boiler Settings

*Copyrighted, 1914, by Osborn Monnett.
†Smoke inspector, City of Chicago.



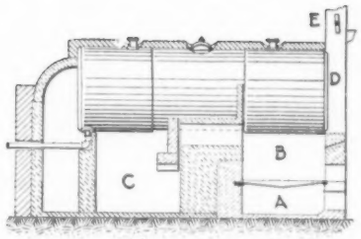

A=5% B=40% C=52% D=57% E=80% F=86% G=100%

FIG. 11- HORIZONTAL WATER TUBE HORIZONTALLY BAFFLED, SINGLE PASS, TUBE SPACING 5×6½ TO 6×7 INCH



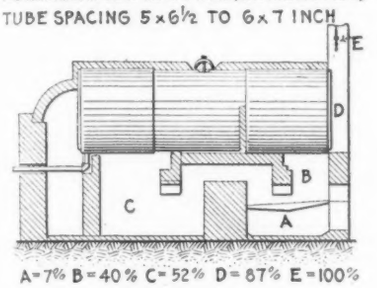

A=7% B=44% C=48% D=70% E=100%

FIG. 12- RETURN TUBULAR BOILER, PLAIN SETTING OLD TYPE DAMPER AND GAS PASSES



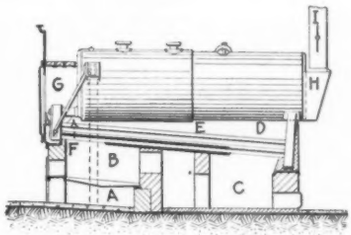

A=7% B=53% C=60% D=79% E=100%

FIG. 13- RETURN TUBULAR BOILER DOUBLE-ARCH BRIDGEWALL FURNACE



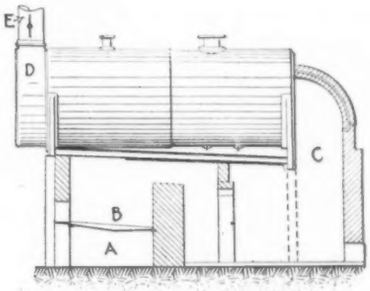

A=7% B=40% C=52% D=87% E=100%

FIG. 14- RETURN TUBULAR BOILER, LOW PRESSURE



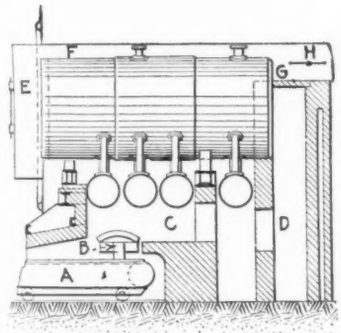

A=7% B=40% C=47% D=47% E=48% F=48% G=50% H=87% I=100%

FIG. 15- KROESCHELL COMBINATION BOILER



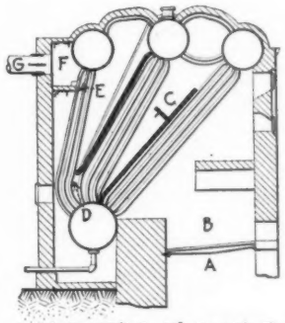

A=8% B=40% C=48% D=75% E=100%

FIG. 16- LYONS BOILER



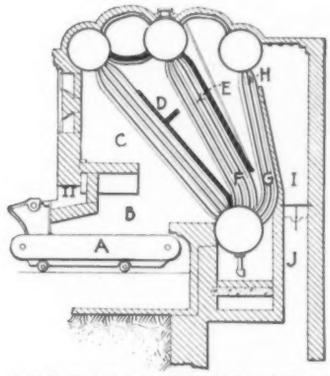

A=5% B=15% C=17% D=35% E=83% F=92% G=97% H=100%

FIG. 17- SEDERHOLM BOILER (3 INCH TUBES)



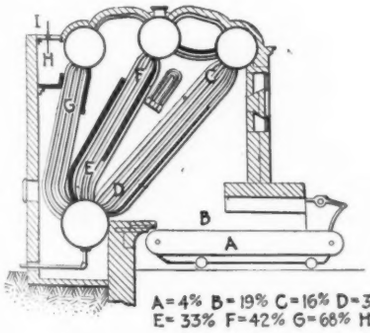

A=8% B=35% C=41% D=49% E=68% F=93% G=100%

FIG. 18- STIRLING BOILER STANDARD SETTING



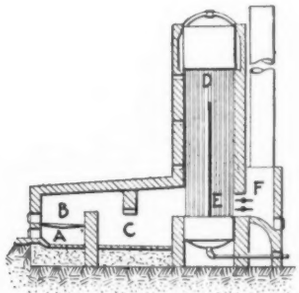

A=5% B=14% C=16% D=29% E=31% F=37% G=59% H=65% I=83% J=100%

FIG. 19- STIRLING BOILER UNDERGROUND BREECHING



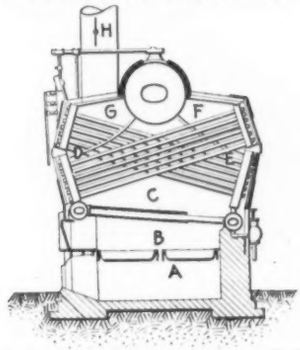

A=4% B=19% C=16% D=33% E=33% F=42% G=68% H=93% I=100%

FIG. 20- STIRLING BOILER (FIVE PASS)




A=5% B=42% C=48% D=25% E=75% F=100%

FIG. 21- WICKES VERTICAL BOILER




A=7% B=45% C=45% D=62% E=57% F=46% G=66% H=100%

FIG. 22- WORTHINGTON BOILER

MORE BOILER SETTINGS, SHOWING DRAFT LOSSES

over the fire, after the breeching losses are added to the draft intensity required at the damper. For instance, in Fig. 11 the percentage of draft over the fire is given as 40 per cent. of the draft at the stack side of the damper. If, on a given job, it is desired to obtain a draft of 0.32 in. over the fire with this boiler, then there will be required at the stack side of the damper a draft that is the equivalent of

$$\frac{0.32 \times 100}{40} = 0.8 \textit{ in. of water}$$

to which must be added the breeching loss before calculating the stack height.

This information is of value also when studying the draft conditions in existing plants. Any unusual drop between two points in a setting will indicate at once that something is wrong.

# Releasing Pawled Elevator Cars

By William Kavanagh

*SYNOPSIS—Why elevators cars pawl in the shaft. What to do to release a pawled car and to liberate the imprisoned passengers. Some mechanical troubles that cause a car to pawl when it ought not to, and how to discover and remedy them.*

Usually if an electric elevator pawls in the shaft it demonstrates that the safeties operated at the proper time and prevented the car from falling to the lowest floor of the elevator shaft. When the safeties operate and lock the car in the shaft at times when such is not required, it indicates that the mechanism controlling the action of the safeties is disordered. Such trouble should be found and immediately remedied. While it is important to know that the safeties are in good order, still a continuous repetition of cars pawling, whether loaded or unloaded, will create dissatisfaction among tenants and give the engineer much worry.

When a car pawls from overloading, the car operator is to blame for allowing too many persons aboard. In the morning, the rush of the passengers is upward, and at this time there are fewer cars pawled than in the evening, when there is a heavy rush of passengers downward. Crowding the cars in the evening often causes pawling, the car operator, being anxious to carry all of the passengers possible, will risk an overload, which causes the safeties to act and lock the car, sometimes between floors.

When a loaded car is pawled between floors, the engineer and his assistants must use good judgment to prevent any undue excitement of the imprisoned passengers, and act quickly to release the car. To do this, one man is sent to the operating board while another is placed where he can see the safeties. Two or more men are posted on top of the pawled car, while one or two are sent to the bottom of the shaft in which the car is locked. The men being placed, the engineer gives the word to unlock the governor. After the governor is reset, the engineer orders the man at the control board to take up the slack, which is done by slightly lifting the car from below or by pulling on the lifting cables. This operation being over, the men at the bottom of the shaft, and also the men on top of the car, are ordered to pull on the safety cable.

All the men will now pull together on the safety cable in the direction that will unlock the safeties. The man watching the safeties from beneath the car can then determine the direction in which the safety cable must be pulled, and the instant the safeties are unlocked the circuit for the car control will become closed, enabling the operator to start the car. The safety clutches being

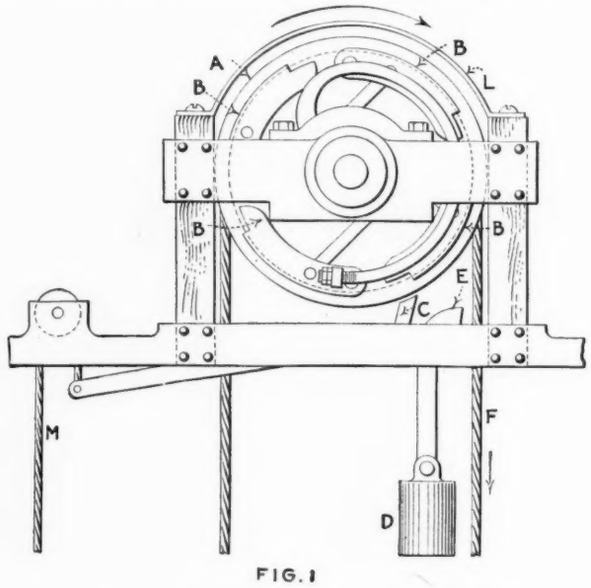


FIG. 1

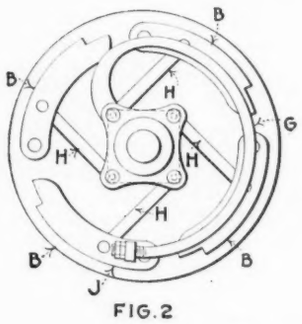


FIG. 2

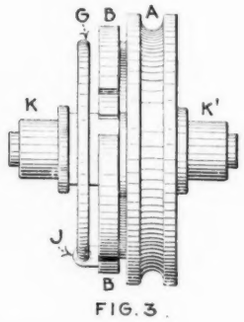


FIG. 3

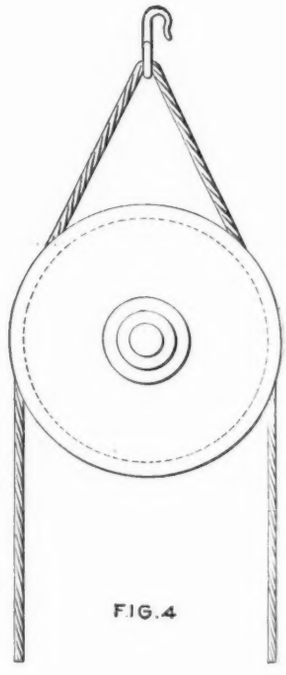


FIG. 4

Views of Parts of Elevator Governor

loosened from the rails, the operator is now ordered to throw the controller on the "up" motion, and the car is brought level with the floor directly above, when the passengers are permitted to leave.

It is not advisable to throw the controller on the "down" motion, especially when the car is filled with passengers. After all the passengers are out, the car is run to the upper limit of travel, and an investigation made into the cause of pawling.

A car will pawl from any or all of the following conditions: (1) If the governor is not properly set; (2) if the safety rope is stranded; (3) if the governor is worn or the governor spring is weak; (4) if the car is suddenly "jumped" into speed; (5) if the car is overloaded; (6) if the safety mechanism permits of creeping.

A governor of the instantaneous type is shown in Fig. 1, and when the car is traveling downward the rotation of the sheave wheel will be in the direction of the arrow. Assume that for some reason the car descends at an abnormal rate of speed. The sheave *A* will be rotated at a high rate of speed, throwing the weights *B* beyond their normal plane, which will cause them to strike the trigger *C*, liberating the weight *D*, the action of which will cause the wedge *E* to bind the cable *F*, locking the safety cable in the governor frame and preventing its further travel. The moment cable *F* becomes locked, the stress thus imposed on it is communicated to the safety mechanism beneath the car. This action causes the safety springs to act on the safety clutches, which grip the car guide rails with a vise-like grip, compelling the car to stop in its descent within a very small distance. When the safety springs act, the circuit controlling the operating board is broken, preventing further rotation of the motor actuating the hoisting and lowering mechanism. If this circuit were not broken, the motor would keep on running and eventually unwind the drum cables, causing considerable labor to straighten out the cables for the proper direction of travel.

Fig. 2 illustrates the governor wheel removed from its frame as shown in Fig. 1. The weights are shown at *B* and the spring at *G*. It will be noticed that there are four tangential levers *H*. Those levers are connected to the square yoke and to the weights as indicated. The spring *G* also is connected to the yoke and the weight *J*. The spring is made fast at this point by means of two small nuts and the tension on *G* can be varied to suit the load or velocity of rotation. If the tension is slight, a low velocity is all that will be required to throw the weights beyond their normal plane, thus permitting them to strike the trigger shown in Fig. 1.

Again, when the levers or pins to which the levers are attached become worn, lost motion will prevail, and the weights will trip the governor even though the tension on the spring is greater than normal. If the nuts at *J* are not set up tight, the tension on *G* will become insufficient, allowing the weights to trip the governor and pawl the car. Fig. 3 is a side view of Fig. 2; it shows the solid brass bushings *KK*, in which the shaft carrying the sheave *A* rotates. If the bearing *KK* becomes worn, the governor wheel or the sheave *A* will cant toward the trigger, tripping the safety mechanism. Whenever a governor wheel is worn sufficiently to permit tripping it must be removed.

Fig. 4 shows the method of removing the worn wheel. The tension sheave in the elevator pit or bottom of the well is raised to its limit of height, and a hook is placed under the governor rope. The rope may now be raised above the wheel as indicated, the wheel removed and a new one put on.

The quickness with which a stalled car may be put in motion depends on how the engine-room force has been trained. With a well trained crew, a pawled car containing, say, a dozen passengers, should be in running order in fifteen minutes. This time may be much shortened if a flat band of strap iron is bolted circumferentially above the governor wheel as shown at *L*, Fig. 1.

When the governor cable becomes locked in the frame, the shock it receives often causes the rope or cable to jump out of the sheave, causing considerable delay to replace it. This iron band obviates this trouble, and again when the governor, unlocking the rope, shown at *M*, Fig. 1, extends the entire length of the shaft, it facilitates matters in getting the car in running condition. Thus we see that where those two additions are made to the governor mechanism, the governor cable is prevented from jumping out of the sheave and can be unlocked from any part of the shaft, saving the time required to reach the roof or pent house where the governor wheel is located.

## Hints on Starting a Compression Plant

By William L. Keil

In many plants the engineer has to occasionally run an ice or refrigeration machine; in others only during the hot season. To those engineers lacking the experience of the refrigeration man, practical hints are usually welcome.

There are many types of refrigeration machines; large ones, small ones, double- and single-acting; some with an oil system, others without (dry system); but they all work on the same principle. Every engineer knows what to do when starting an ordinary water or air pump; he first sees that the suction and discharge valves are open before he turns on the steam. About the same things are done when starting a refrigeration machine, for the ammonia compressor is really a high-class pump.

When starting a compressor, the first thing is to see that the discharge valve is open. As all double-acting machines have equalizers, see that they are open, and then start slowly. Next, slowly open the valves on the suction line, then turn the oil on to lubricate the valves and then the water to keep the compressor cool, or the oil, if the machine has an oil system. Now close the equalizing cocks Watch the back-pressure gage, if it indicates the pressure one finds best to carry, the main liquid valve should be opened slowly. The water over the ammonia condenser should not be turned on until the high-pressure gage indicates the pressure usually carried.

While the machine runs the frost may come back to the compressors from two causes: From some liquid that laid in the suction line, or from one or more regulating valves being open too wide. In the first case let the machine run a little faster; if the frost does not disappear soon, look at the return pipes of the different rooms. Be sure to shut off on the room from which the pipe is most heavily frosted, for the frost on the return from the

room where the frost comes back strongly may travel along the return line of the other rooms. If such is the case, it is difficult for the inexperienced engineer to tell which one of the rooms freezes back most. To locate the room or return, wet the finger tips and touch the return; if the fingers stick then the room from which the frost comes has been located. What has been thus far explained applies to the direct system only.

### The Indirect System

By indirect system is meant a system where brine is cooled to freeze water or produce frost around the coils in the different rooms through which it is circulated by means of the brine pump. For the smaller refrigeration plant, hotels, etc., this system is in use more extensively than the direct system.

The brine tank should always contain brine enough to entirely submerge the coils. It must not be less than 70 nor more than 90 deg. Baumé and should be constantly agitated; it must never be cooled lower than 8 or 10 deg. F. When down that low, the machine may be stopped while the agitating pump is kept running.

# Tom Hunter, Hoisting Engineer

By Warren O. Rogers

*SYNOPSIS—Several kinds of mine locomotives were seen in operation, one of the gasoline type. A combination electric locomotive and haulage system was found at one colliery, the haulage engine drawing the loaded cars out of the mine, and the electric, coming out light, hauled the empty cars back into the mine.*

It is the general supposition among those not familar with present-day coal-mine practice that mules are used almost exclusively in coal mines for hauling coal from the working face to the bottom of the shaft. I was

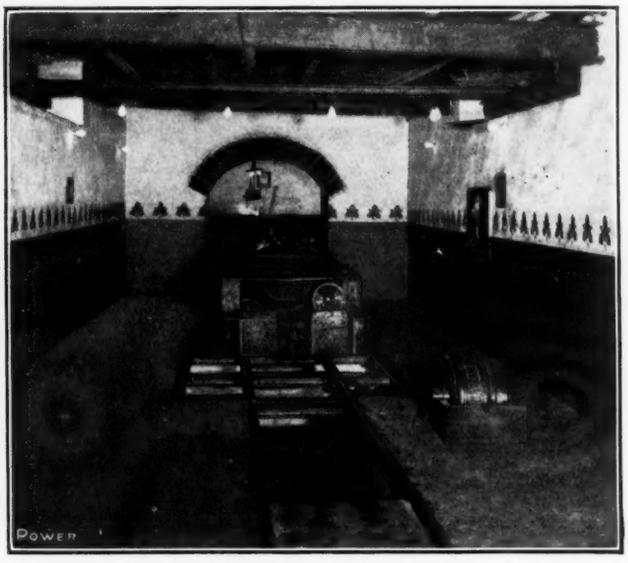



Fig. 1. Electric Locomotive Room in Mine

surprised during my travels about the mines to note how extensively air and electric haulage was used, and to find that in the larger mines mules were worked only for gathering, some type of locomotive being used for the long hauls.

In our travels Hunter and I had run upon various kinds of mine haulage, with the exception of steam locomotives, which had been tried, Hunter said, but owing to the volume of smoke and gases given off had been discarded.

In our conversations, Hunter had also stated that air locomotives were used in deep, gaseous mines, because they operate without spark or fire of any kind and at the same time added to the ventilation, supplying clean air to that in the mine. The disadvantage of the air locomotive is that it is bulky and requires high and wide entries in which to run. More than that, it cannot go far from a charging station, which renders its use less flexible than the electric or the gasoline locomotive. Then there is the upkeep of not only the locomotives but of the pipe lines, when high pressures are maintained.

"Simplicity is the prevailing feature of the electric locomotive," said Hunter, as we stood looking at one in the motor room, Fig. 1, down in No. 9 colliery of the Pennsylvania Coal Co. This repair room was 10x65 ft. in width and length and 12 ft. high. The roof was of natural slate, which was reinforced by I-beams, as shown. The walls were cemented and painted and the floor was of concrete. A tool room built in the stone formation is shown at the rear of the electric locomotive.

"You see," said Hunter, "an electric locomotive has really but one rotating part and mechanically it is the simplest motor used about a mine; so long as electricity is supplied it will do its work, providing nothing burns out. As there is danger of gases being ignited from sparks formed between the trolley wheel and the wire, the electric locomotive is not the machine to use in a gaseous mine.

"You have read of trolley lines costing so many dollars per mile to construct, but you can bet every bean you've got that mine tracks and equipment cost money, too. The expense of installing the trolley wire and feeders alone is no small item, and the rails have to be bonded to carry the return current, which adds to the expense. This and the cost of the locomotive are but a small part of the entire expenditure for electrical equipment, including power-plant apparatus. Aside from the danger from gas ignition, there is the danger of the workmen being shocked."

"From your point of view, the electric and air locomotive is not in it with mule haulage for safety or cheapness?"

Hunter gave a grin before answering and then said. "Nobody about a mine will bank on a mule being safe, especially from a stern exposure. He can haul an exceedingly heavy load, but his mileage is small and he is liable to injury. Now about the locomotive. I don't disapprove of them; I just happened to tell you of some of their disadvantages. I don't know how some of the large mines could get along without them and still maintain their output of coal. You remember at No. 35 Col-

liery of the Berwind-White Co., at Windber, we saw a 20-ton six-drive electric locomotive drawing something like 110 empty coal cars (Fig. 2).

"They were to be taken into the mine and a loaded train brought out while dozens of mules would have made about a quarter of the trip in with empties. At this company's mines a railway car is loaded with coal every few minutes. To get the output of the mines to market, about 4,285,521 tons per year, would take a bunch of mules."

"Just a few," was the only reply I could make.

In most mines employing electric locomotive or haulage engines, each is operated separately, but at No. 28, Pardee, colliery we found a second-motion haulage engine, Fig. 4, working in connection with an electric locomotive. The pinion on the engine crankshaft meshes with a gear wheel keyed to the drum shaft. The rim of the gear is made in six sections, and if a tooth breaks, that section can be replaced at small expense. The drum is driven by a friction on the shaft. The brakes are operated by steam. The engine draws the loaded cars from the mine, but no tail rope is required as the electric loco-

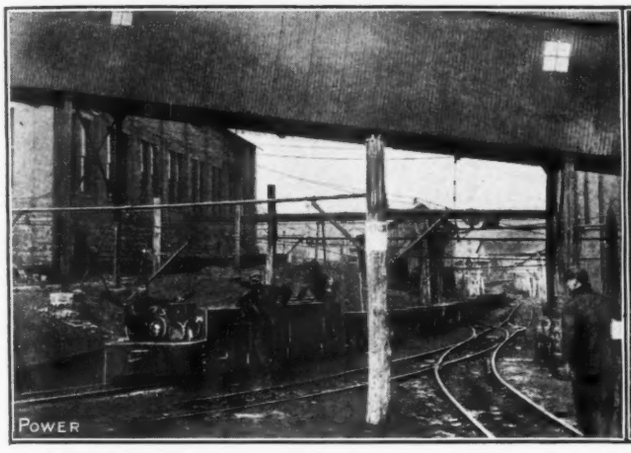



FIG. 2. TWENTY-TON LOCOMOTIVE DRAWING 110 EMPTY MINE CARS

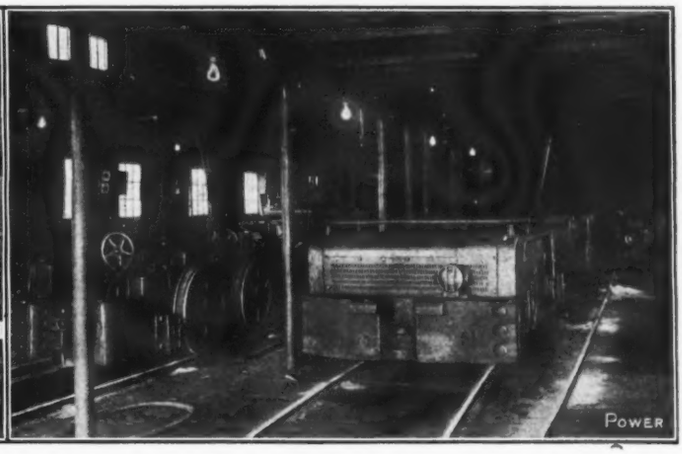



FIG. 3. LOCOMOTIVE BARN AND REPAIR SHOP

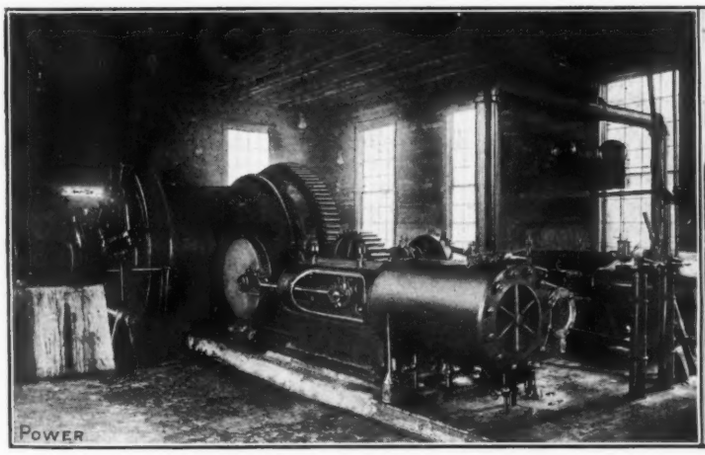



FIG. 4. HAULAGE ENGINE. A LOCOMOTIVE DRAWS THE EMPTY CARS INTO THE MINE

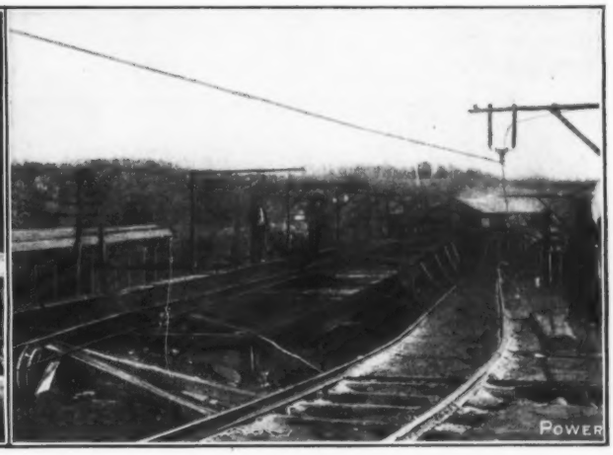



FIG. 5. AS THE CARS ENTER THE MINE, THE HAULAGE ROPE IS SNAPPED FROM ONE TRACK LEVEL TO THE OTHER

Several days later we came to the Moshannon colliery No. 33 of the Pennsylvania Coal & Coke Co., at Patton, Penn. This mine is electrically operated and an examination of the motor house, Fig. 3, was interesting. There was a 10-ton locomotive with equipment of 15-ton rating. The motor and driving wheels were connected by an intermediate gear. The gear wheels were made of a spider shrunk to the wheel shafts, and the toothed rims were made in sections, so that when the teeth became worn or broken a new gear rim could be bolted to the spider by six 1⅛-in. bolts, without disturbing any other part of the machine. All ordinary repairs of the electrical equipment are made at the mine, a machine shop being at one end of the locomotive house.

motive draws the empty cars into the mine, and follows the train load of 70 tons from the mine up a 5 per cent. grade in places.

It is figured that this is cheaper than to have the locomotive do all the work. The locomotive was used to draw the empties from the tipple up the incline, Fig. 5, and then to control the empty train going into the mine and to also draw the haulage cable into the mine ready for the engine to haul out another loaded train. While the cable was being drawn into the mine the winding drum ran loose, the engine being stopped.

By referring to Fig. 5 it will be seen that the loaded cars are on the upper track and that the empties are switched back, after dumping, to the lower track. The

haulage cable is hooked onto the rear end of the last car of the train. In order to get the cable back to the upper track after the empties have reached the same level, the engineer of the haulage engine puts the brake on the drum, which has been running loose on its shaft. This snaps the cable up over the timbers, shown at the right of the platform, onto the rollers beside the track, ready for the next loaded train. The cable is shown just before reaching the rollers upon which it runs.

While at this colliery, the sky became overcast and rain threatened to spoil the rest of the day. Nevertheless, we made our way to No. 35 colliery of the same company. As we picked our steps over the uneven ties of the railroad track, Hunter said, "Did you ever see a gasoline mine locomotive?" Upon my negative reply he continued: "They haven't been over 10 years in this country, but they were used in Europe about the time the automobile came into service. They are operated in mines the same as air or electric locomotives, and eliminate the necessity for an outside power plant."

When we arrived at the mine we found a Whitcomb gasoline locomotive just coming out of the level with 22 loaded cars of coal, or approximately 19 tons, total. The grade in places was over 5 per cent., but in some parts of the mine the speed was approximately eight miles per hour. The machine is shown in Figs. 6 and 7.

"That motor is made in a number of sizes," remarked Hunter, watching the last of the empty coal cars disappear in the hole in the hill, "ranging from 2½ to 16 tons. All are fitted with four-cylinder, four-cycle horizontally opposed engines ranging from 20 to 125 hp. The drive is from the engine into the transmission, which provides for two speeds in either direction."

FIG. 6. GASOLINE LOCOMOTIVE AND TRAIN OF EMPTY CARS

"How is that accomplished?" I asked, as we examined the locomotive after its return from the mine.

"Well, one of the driving shafts has a bevel pinion which engages with two bevel gears in the transmission. On the back of these two gears are clutches, and as the gears run in opposite directions, on account of meshing with the one pinion, a forward or reverse motion is given.

"On the forward or reverse shaft there are two spur pinions that engage with two spur gears on a lower shaft. On these gears are also fitted clutches which provide for high and low speed, giving a gear capable of making four miles an hour on slow speed and eight miles on high speed, with the engine running at about 500 r.p.m. The engine has a range of speed of from 300 to 750 r.p.m. The front high- and low-speed shafts are driven by a double chain drive and from the front to the rear axle by a chain drive, so that all four wheels are drive wheels. This machine, as, in fact, all others, will develop a tractive effort of about 20 per cent. of its weight."

As we left the mine a drizzle began, and before we reached the nearest hotel we were fit subjects for a steam-

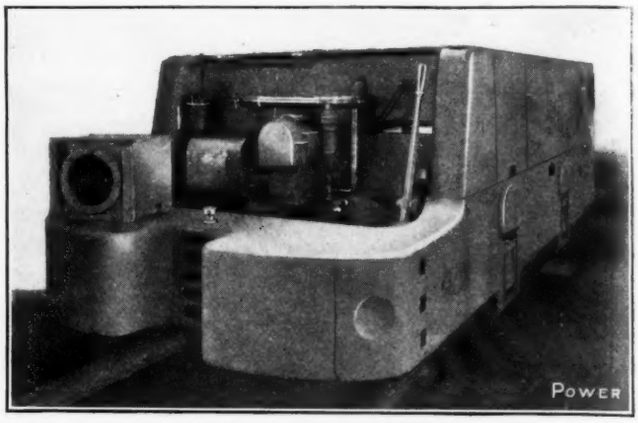



FIG. 7. OPERATOR'S END OF GASOLINE LOCOMOTIVE

drying establishment. After supper that night, while in conversation with some mining men, we learned of a mining proposition that sounded mighty interesting, and we decided to look it over the next day. The rain was still beating against the windows as we went to our rooms, and after tumbling into a cold, damp-feeling bed, I finally went to sleep, inhaling the mixed odor of new paint and insecticide.

## Air-Gap Equalization

In the case of a series-connected multipolar armature, for every conductor in a given position under a pole of given polarity, there is in series with it another conductor in the same relative position under a pole of opposite polarity. Therefore, if on account of excessive bearing wear, or any other reason, the air gap is greater on one magnetic field, there is in series with it a conductor in a strong magnetic field. As such an armature has only two paths through it, unevenness of the air gap around it does not affect the distribution of current in the armature conductors.

In a multiple-connected armature, however, there are as many independent current paths in the armature winding as there are poles in the machine and equalization of the total current through the several independent paths is affected by unequal distribution of the air gap. Equalizing connections between equipotential armature conductors help to equalize the current among the different paths, but there is a limit to the capacity and the effectiveness of these equalizers. For this reason, modern units are generally constructed to permit of equalizing the gap.

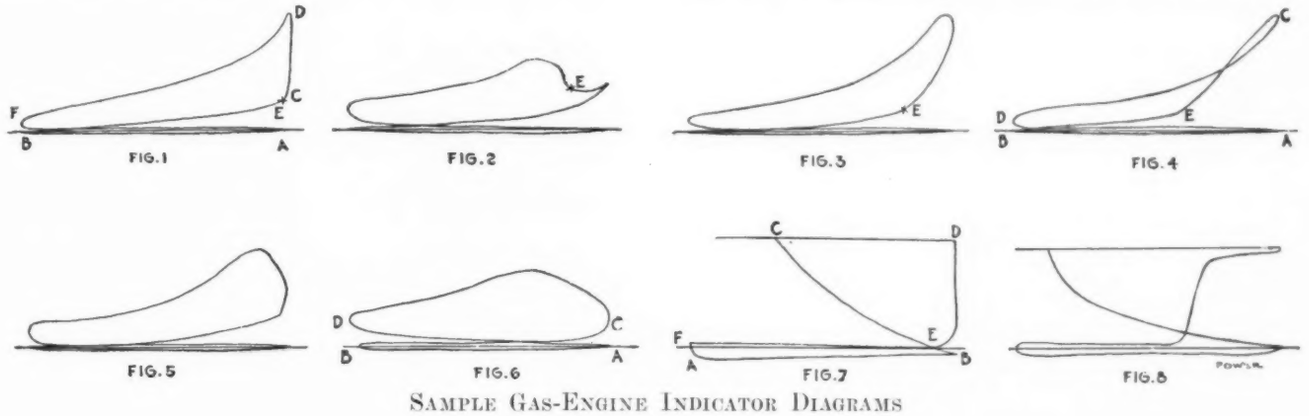
An operator complained that the equalizer rings were heating more than they should and that the brushes were sparking. Inspection showed that wear in the armature bearings had let the armature down, thereby making a small gap at the bottom and a large one at the top. As the machine had no air-gap equalizing devices, new bearings had to be fitted.

# Gas-Engine Indicator Diagrams

By George W. Muench

*SYNOPSIS—How some of the common gas-engine troubles, such as improper timing of valves and ignition, preignition, faulty compression, excessive back pressure, etc., may be detected by the indicator diagram.*

As a trouble finder, the indicator is not used so universally in gas-engine operation as with steam engines. Its use is necessary for determining the indicated horsepower of a gas engine, for in this way only can the true mean effective pressure be found. However, it can be made to serve a large number of other useful purposes, as a diagram properly taken will show the timing of the ignition, the valve setting, the quality of the mixture, the exhaust back pressure, the preignition, the condition of compression, and the other conditions affecting the proper operation of the engine. As a rule, it is not as simple to operate an indicator on a gas engine as on a steam engine; also, higher pressures and sudden changes in pressure must be handled.




Sample Gas-Engine Indicator Diagrams

Fig. 1 represents a normal diagram from a four-stroke-cycle engine. The line *AB* represents the suction stroke, slightly below the atmospheric line, and *BC* represents the compression stroke with the explosion occurring at *E*, the pressure jumping quickly to a maximum at *D*. The power or expansion stroke is represented by the line *DF*. At *F* the exhaust valve opens slightly before the completion of the stroke and *FA* represents the period of exhaust. The area included between the suction and the exhaust lines represents lost work, therefore, all attempts should be toward keeping this as small as possible. Comparing other diagrams with the ideal, the defects are easily located.

Fig. 2 shows a diagram with ignition too late, the explosion occurring at *E*, beyond dead center some distance outward on the expansion stroke.

In Fig. 3 the ignition is too early, the explosion occurring at *E*. Figs. 2 and 3 are actual diagrams taken on an engine.

Premature ignition is shown in Fig. 4; *AB* representing the suction stroke. The compression stroke was interrupted by the ignition at *E*. This too early ignition caused the expansive power of the burning gases to be entirely spent before the end of the compression stroke, so that on the starting of the expansion stroke the pressure immediately dropped, and expansion occurred from *C* to *D*, part of the time the pressure being less than during the previous compression stroke, causing the negative loop shown. Under these conditions but little useful work is performed.

Figs. 5 and 6 are actual diagrams, the former showing a slow-burning mixture. The time of ignition was not bad, but maximum pressure was not reached before the piston had traveled a considerable distance on the power stroke. The indicator diagram shows distinctly why it is essential in gas-engine work that the time of ignition must change with the quality of the mixture to get the best results out of the engine.

A variety of troubles are indicated in Fig. 6. In the first place, the compression is very poor, as is shown by the slight rise of the line *BC*. Also, as in the previous case, the mixture is slow burning and the back pressure is high, there not being enough valve lift, or some other obstructions are preventing the rapid escape of the burned gases, as shown by the line *DA*, the line remaining far above the atmospheric line practically its entire length.

Although showing a high back pressure, this diagram does not show clearly the exact time of opening and closing the exhaust valve. For accurately determining the exact valve setting of a gas engine by means of the indicator, it is necessary to have a special low-pressure spring attachment, which consists of a stop limiting the travel of the indicator piston and preventing damage to the instrument. This makes it possible to use very low-pressure springs and, therefore, arrive at the true valve setting, which is essential for economical operation. The valve-gear becomes worn, the valves fouled and stick, the passages obstructed, and other troubles vary the valve setting, which means a loss in power.

Fig. 7 shows a diagram taken with an 8-lb. spring, *AB* is the suction line and *BC* shows part of the compression, the stop preventing further travel of the pencil at *C*. The diagram does not trace the cycle, but at *D* the pressure is low enough to allow the pencil movement. The sudden drop *DE* represents the release of the gases, the rest of the exhaust stroke being *EF*.

Fig. 8 is a stop diagram showing the exhaust opening too late.

# Test of Wheeler Turbo Air Pump

A high-vacuum surface-condenser air pump has small relative capacity in terms of free air. The air leakage of a large turbine and surface condenser should not exceed 10 cu.ft. of free air per minute. When this air is withdrawn from the condenser it is at an exceedingly low pressure, even lower than the absolute pressure within the condenser, which is the sum of the vapor and the air pressures. To obtain a high vacuum it is necessary, therefore, that the air be withdrawn at a pressure of a fraction of an inch of mercury, and a volume of 1000 to 10,000 cu.ft. per pound.

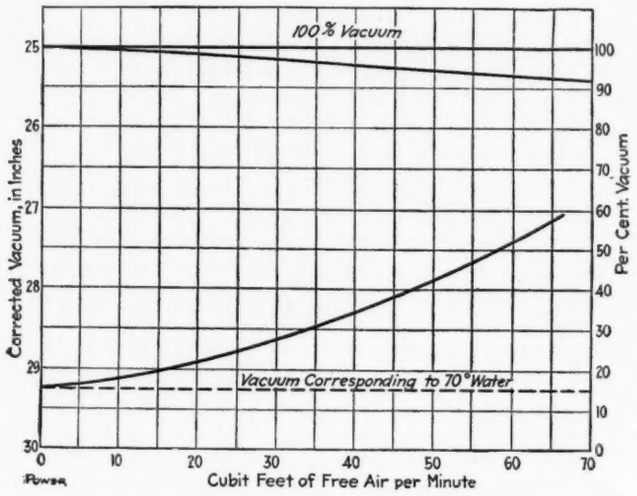



FIG. 1. CURVE OF TEST SHOWING AIR CAPACITY AND VACUUM OF A TURBO AIR PUMP WITH 70 DEG. WATER

With a pump capable of this duty, there remains but two hindrances to the attainment of very high vacuums at the turbine exhaust. The first of these is the quantity of circulating water and its temperature. Assume the water is at 60 deg., then if a 29-in. vacuum is desired, corresponding to a steam temperature of 79 deg., it is evident that the water cannot take up heat when its temperature has gone above 79 deg., in theory, and in practice, above 70 or 75 deg., since some "heat head" is necessary to cause the transmission of heat. If it were required to heat the cooling water up to the temperature of the steam, an infinite amount of tube surface would be needed.

The second hindrance to the attainment of extremely high vacuums is the loss in pressure between the turbine exhaust and the air-pump suction, due to the resistance of the tubes; in other words, the hydro-dynamic loss. This may be reduced to a few tenths of an inch of mercury by the proper arrangement and spacing of the tubes.

It is evident from the foregoing that if sufficient cooling water is used in proportion to the steam to give a rise in temperature of the water of only 10 or 15 deg., it is possible to obtain a vacuum of 29 in. with 60 deg. inlet cooling water, provided the air pump will maintain a vacuum 0.1 to 0.2 inches higher; that is, 29.1 to 29.2.

This is done with modern types of rotary air pumps, with 70-deg. water, instead of 60 deg., as shown by the test of a turbo air pump, reproduced in the chart, Fig. 1. The pump is shown in Figs. 2 and 3. During the test the temperature of the water was 70 degrees. The pump maintained a vacuum 100 per cent. of the theoretical, with closed air suction, and with 10 cu.ft. of free air per minute load a vacuum of 29.1 in., corresponding to 99.7 per cent. of the theoretical. With 18 cu.ft. of free air load, the pump maintained a vacuum of 29 in. The vacuums with increasing load up to 65 cu.ft. of free air per minute are given by the curve.

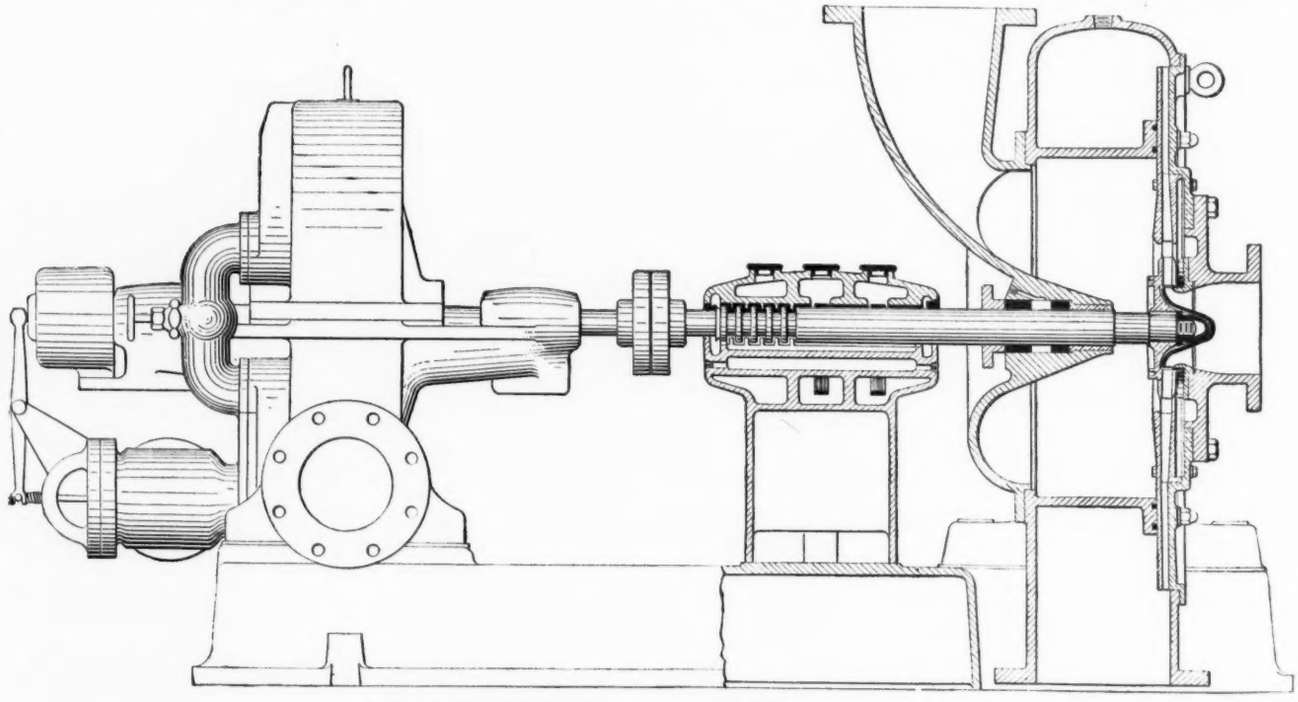


FIG. 2. CROSS-SECTION OF A TURBO AIR PUMP

The design of the turbo air pump, which is built by the Wheeler Condenser & Engineering Co., Carteret, N. J., and is similar to that of the German pump built by the Allgemeine Elektricitäts Gesellschaft, Berlin, is shown by the engravings. The pump has a high-speed small impeller, a ring of diffusion channels and a casing. The impeller discharges water in separate streams into the fixed compression or diffusion ring, whose blades cut the jets into a large number of plugs or layers, which close the entire section of the channels and force the entrapped air out against atmospheric pressure. Air is admitted to the center of the casing by a large nozzle on

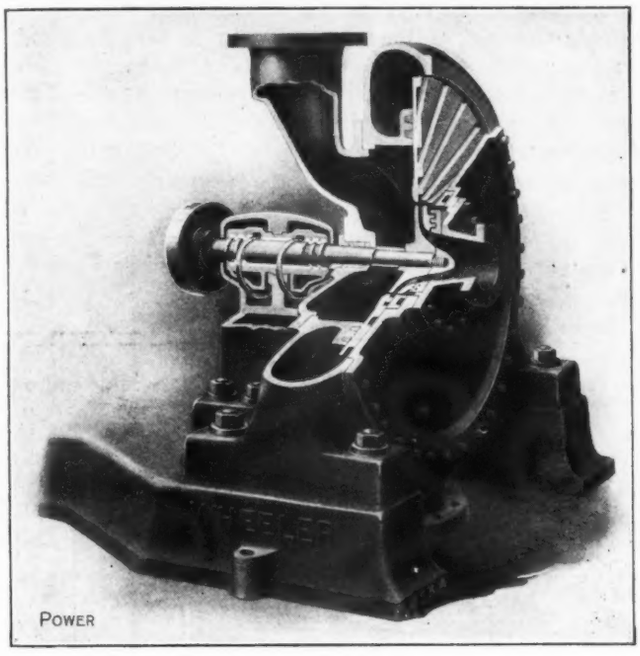



FIG. 3. WHEELER TURBO AIR PUMP

the bearing side of the pump and is drawn into the diffusor all around the impeller. This gives a large capacity for a small-diameter impeller, rotating at very high speed, and is suitable for directly connected turbine drive.

## Improved Hot-Blast Heater

In the heater illustrated, Figs. 1 and 2, an attempt has been made to eliminate the strains on the joints by taking care of the expansion and contraction and to avoid air binding and water-hammer. The straight tubes, all of the same length, are expanded into the front and rear headers, consisting of one-piece boxes. In line with the tube ends are screw plug holes for access in rolling in the pipes and for inspection, cleaning, etc. The tubes are expanded in reamed holes and the ends of the tubes are turned smooth. In the rear header the tubes are expanded against the cast iron. In the front header copper ferrules are used. This header is divided into two parts, the lower being supported by a roller which rests upon an iron plate upon the foundation, and the upper half by a roller resting upon the lower half, thus permitting independent movement.

The steam, or fluid, introduced through a suitable connection into the upper part of the front header, flows through slightly inclined tubes to the rear header, descends to the lower part of the latter and returns through the lower half of the bank of tubes to the lower part of the front header, passing thence to the drip or outlet connection. The circulation is thus positive without short-circuiting or pocketing and the steam assists the

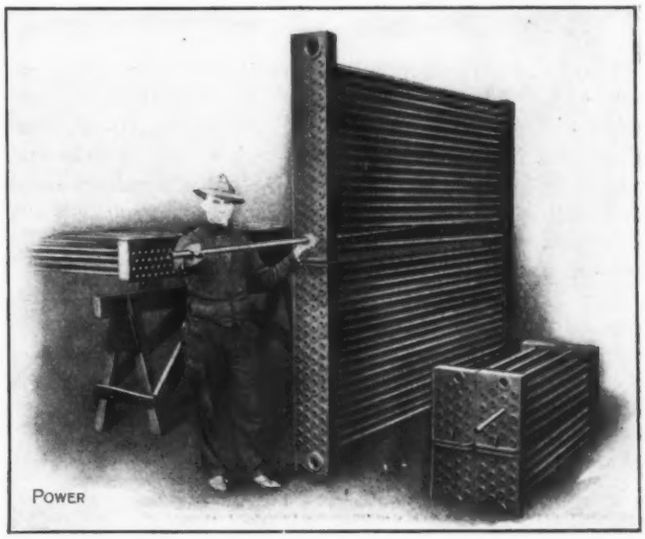



FIG. 1. BOX-HEADER TYPE HOT-BLAST HEATER COIL

air and water of condensation in the natural direction of flow by gravity.

The sides of the headers are set tightly together, rendering unnecessary special housing or covering on the two sides and leaving only the top or the bottom to be inclosed, depending upon whether the heater is to rest on

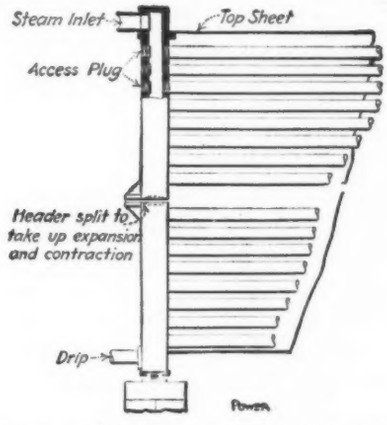



FIG. 2. SHOWING PLUGS OPPOSITE THE TUBES' ENDS

the floor or to be suspended close to the ceiling. If it should be desired to apply insulating material, this may be done easily as the access plugs are of the socket type and are flush with the surface of the header.

This type of heater coil is manufactured by the Green Fuel Economizer Co., Matteawan, N. Y.

**Significant Operating Saving**—The S. R. Smith Infirmary, on Staten Island, N. Y., saved $2000 in operating expenses last year over the previous one by the installation of its own generating plant. It formerly had a heating plant only and bought current from the Richmond Light & Ry. Co. In spite of the saving the load was greater during the past year than before. This saving, though not so large, is significant in view of the size of the plant, which is rated at only 70 kw.

# Connecting Series and Shunt Motors

By F. A. Annett

*SYNOPSIS—The proper connections between the starter and motor and how to detect wrong connections.*

It is the general practice among electrical manufacturers, not only to label carefully the terminals of their apparatus, but to send with each piece of equipment instructions for connecting up as well as for its care and operation. These instructions are usually accompanied by a well executed picture of the motor, showing how the terminals are located, each terminal being carefully marked and connected to a starting box similar to that shown in Fig. 1, which represents a series motor. However, as the terminals of various makes of motors may be brought out differently, a representation of the connections of one make may not apply to another, unless certain simple rules are followed. When it comes to this, the picture may be dispensed with and a diagram used as in Fig. 2. There is one thing necessary, the diagram must represent the motor it is used for; that is, if the motor is series wound, the diagram must represent a series motor as the one in Fig. 2; if it is shunt wound, it must represent a shunt motor, etc.

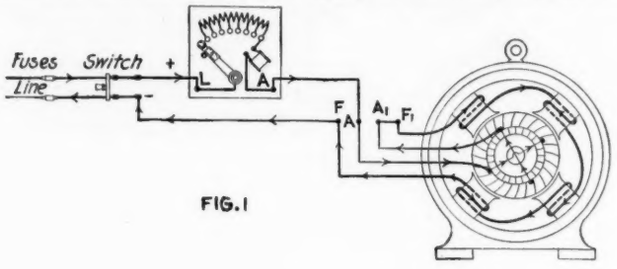



FIG. 1

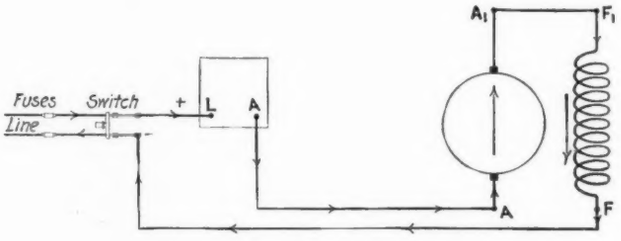



FIG. 2

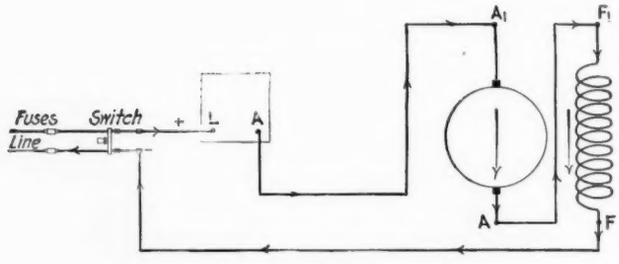



FIG. 3

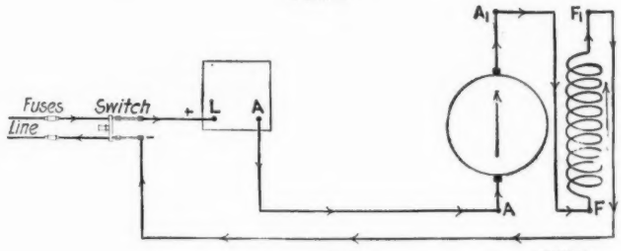



FIG. 4

POWER

## Series Motor

To connect up a motor from a diagram, first determine which are the armature and which the field terminals, and what kind of a motor it is, either by inspection or by testing. Assume a condition as in Fig. 1, where the two center terminals represent the armature circuit; as can be seen, they come from the brushes and are marked $A$ and $A_1$. The two outside terminals are the field and are marked $F$ and $F_1$.

A good practice in connecting up a motor from a diagram is to start from one side of the switch and work around to the opposite side. In this case, start from the positive side of the switch, which in Fig. 2 runs to the terminal marked $L$ (sometimes marked "Line") on the starting box. After making this line connection, next in order will come the other terminal on the starting box, which is marked $A$. By referring to Fig. 2, it will be seen that one wire runs from this terminal to one of the armature terminals marked $A$, although in this instance, it could be any terminal on the motor as the machine is series connected and there is but one circuit through it. This is true only for the series motor, therefore, it is best to make a practice of connecting the machine according to the sketch. The following can be laid down as a hard-and-fast rule for any motor:

Connect terminal $A$ (sometimes marked "Arm") on the starting box to one of the armature terminals only on the motor and this part will always be right. Next connect the other terminal of the armature to one of the field terminals, which, in Figs. 1 and 2, are shown $A_1$ to $F_1$, although $A_1$ could be connected to $F$. Finally, connect the remaining terminal $F$ on the motor to the negative side of the switch. Now if the connections are traced out in Figs. 1 and 2, it will be seen that they both run the same; i.e., from the positive terminal on the switch to the $L$ terminal on the starting box; from $A$ on the starting box to the armature connection $A$; from the armature terminal $A_1$ to the field terminal $F_1$ and from the remaining field terminal $F$ to the negative side of the switch.

In a diagram, such as Fig. 1, the connections may be so shown as to produce a definite direction of rotation, while that in Fig. 2 does not indicate any particular direction. After the motor has been connected up, however, and is working properly, all that is necessary in order to reverse the direction of rotation, is to interchange either the armature or the field connections, as in Figs. 3 and 4. By tracing out the current, it will be seen to flow as indicated by the arrows. In either case, the connections in Figs. 3 and 4 will give a different direction of rotation from that in Fig. 2.

## Shunt Motors

What has been applied to the series motor can also be applied to any type of motor. In Fig. 5 is shown a shunt motor connected to a starting box. Every terminal on the machine and starting box is indicated in its proper

location, but, as in the series motor, these connections can be shown in a diagram, as in Fig. 6. The starting box for the shunt motor, however, has three terminals on it, the object being to connect the field across the line at the instant of starting. This will be made clear by referring to Fig. 5.

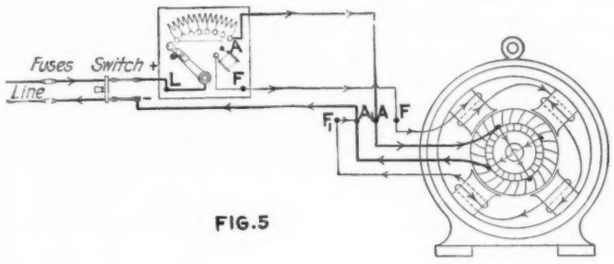


FIG.5

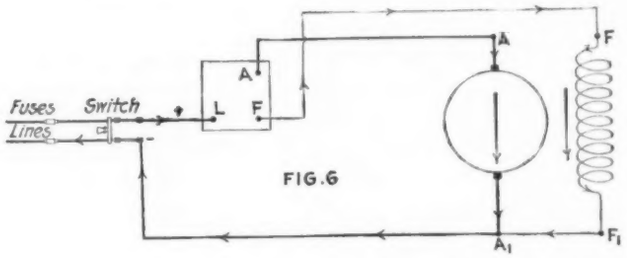


FIG.6

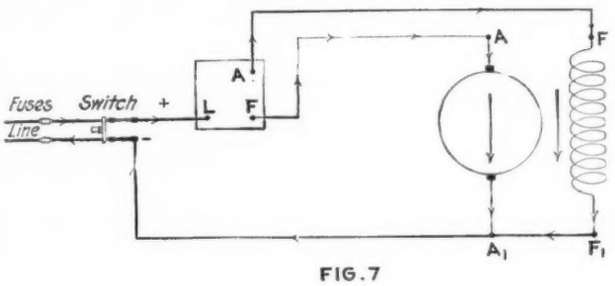


FIG.7

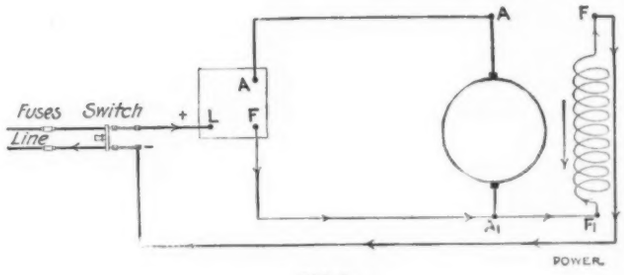


FIG.8

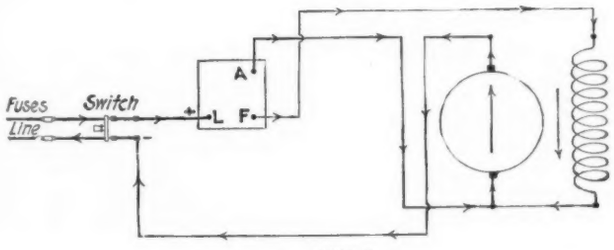


FIG.9

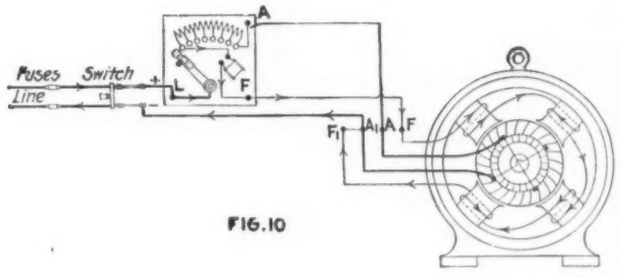


FIG.10

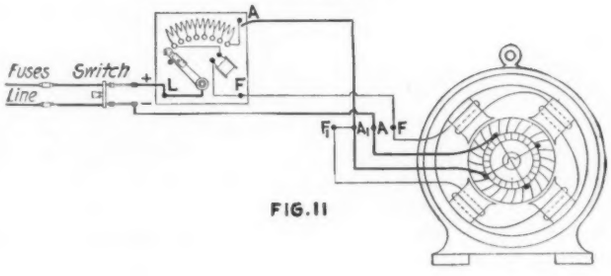


FIG.11

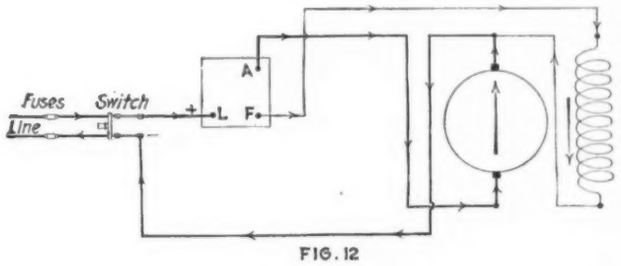


FIG.12

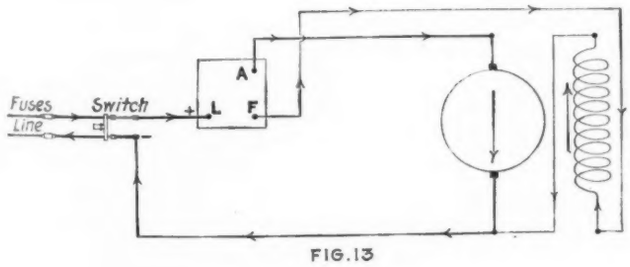


FIG.13

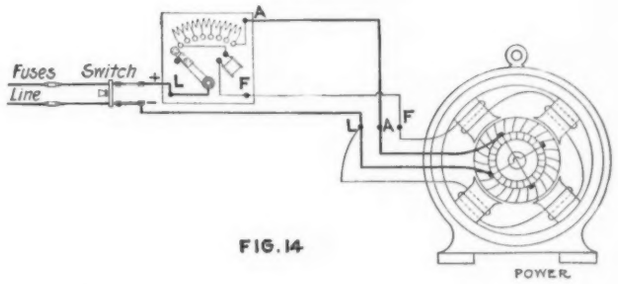


FIG.14

When the arm on the starting box is moved to the first contact of the starting resistance the field current will flow as indicated by the arrowheads; that is, direct from the line through the no-voltage release coil on the starting box to the field terminal *F* on the motor, and through the field back to the line, thus applying full-line voltage across the field terminals at starting. This produces a maximum field strength, which develops a maximum starting torque for a given current in the armature. By tracing out the armature current with the starting-box arm on the first contact, it will be seen that all the resistance is in series with the armature and the current flows as indicated by the arrowheads. As the arm is moved over toward the no-voltage release coil, the resistance is cut out of the armature circuit and cut in the field. The starting resistance in series with the field has little effect, for the resistance of the field is so high compared with the starting resistance, that it is almost

negligible. This additional terminal *F* on the starting box (sometimes marked "Field") does not greatly increase the complications of the connections, although more care should be taken in making the connections than in the series motor.

In the series motor the armature connections on the starting box could be connected to any terminal on the motor and be connected right; but not so for the shunt machine, the armature terminal on the starting box must connect to one of the armature terminals on the motor, and the terminal on the starting box marked *F* (or Field) must always be connected only to one of the field terminals of the motor, as indicated in Figs. 5 and 6, the remaining armature and field terminals being connected together and directly to the line switch. Care should be taken to have the motor connected properly before attempting to start it, as serious results may occur from wrong connections. For instance, if the connections were made as in Fig. 7, the field terminal *F* on the starting box being connected to the armature terminal *A* on the motor and the armature terminal *A* on the starter to the field terminal *F* on the motor. If the motor is started under these conditions, the no-voltage coil on the starting box will become very hot, and if left in circuit long enough, it would be burned out. If the motor was starting under load, the probabilities are that the coil would be burned out almost instantly.

Another mistake is that shown in Fig. 8; that is, the field terminal on the starting box is connected to the armature and field on the motor and the field connection on the motor to the line switch. By tracing out the current it will be seen that the fields are across the line, but both armature terminals are connected to the starting box. This will give full voltage across the field, but zero voltage across the armature, and the motor will not start; although, if the arm of the starting box is thrown over against the no-voltage release coil, it will be held there. No serious results would occur from this connection. Such mistakes are not likely on the large motors, as the field terminals on the starting box and motor are too small to receive the large wires of the armature and line.

One of the most common errors in connecting up a motor is that shown in Fig. 9. The armature terminal on the starting box is connected to one of the armature and field terminals on the motor and the remaining armature terminal of the motor is connected direct to the line. A shunt motor thus connected will start with a good torque at the instant of starting; that is, when the arm of the starting box is moved upon the first contact the current can flow from the positive side of the line through the field and the armature and back to the opposite side of the line and give full field strength. The armature current also flows in the direction indicated, and as far as the starting torque is concerned, it will be about the same as that when the motor is connected properly. As soon as the armature begins to turn, it generates a counter electromotive force. Since the field is in series with the armature the counter electromotive force will decrease the effective voltage across the field and, as the starting resistance is cut out, and the motor speeds up, the field becomes weaker and the motor races. If the motor is started under load there is danger of the starting resistance being burned out, for instead of the starting current becoming less as the motor comes up to speed, it becomes greater, and by the time two or three points of the resistance are cut out, the starting box is very hot or the fuse has blown.

After the motor has been connected, it is advisable to make a test to see that there have been no mistakes in making the connections. This can be done as follows: After everything is in readiness to start, disconnect the armature connection on the starting box as in Fig. 10, then close the switch and bring the starting-box arm on the first point. If the motor is connected properly, as in Fig. 10, the field circuit will be complete and will be indicated by a spark if the starting-box arm is allowed to drop back to the off position or the switch is opened. Care should be taken not to open the circuit too quickly, as this induces a very high voltage in the field. If the arm on the starting box is brought over against the no-voltage release coil, it will be held in this position until the switch is open or the arm forced away from the coil.

With any other combination of connections, the field will be open-circuited if the armature connection on the starting box is open, as in Fig. 11, which is the same connection as in Fig. 9. This will be indicated by the absence of a spark, as when the starter arm is pulled back from the first starting contact to the off position, although the open circuit in the field may be tested for in the same way if the motor is connected up properly.

Connecting up a shunt motor from a diagram, as in Fig. 6, involves no particular direction of rotation, but, as in the series machine, after the motor has been connected correctly, and is found to operate properly, the direction of rotation may be reversed by interchanging either the armature or the field connections, as in Figs. 12 and 13, respectively. Fig. 12 shows the armature connections interchanged; Fig. 13, the field connections interchanged. The connections in Figs. 12 and 13 will cause the armature to turn in the opposite direction to that shown in Fig. 6. It will be seen that although the current has a different direction in the field and armature in Figs. 12 and 13, the motor is connected the same as in Fig. 6, and this is the only possible connection that can be made and have the motor operate properly.

A mistake that is often made in attempting to interchange the armature connections to reverse the direction of rotation is to interchange the armature connection with that of the line, which is the same as that in Fig. 9, and will, therefore, produce the same results as explained for that connection. Care should be taken always to remove the jumper between the field and armature connections and to connect it to the opposite armature connection with the line wire. This mistake is often made on machines which have their leads connected to three terminals, as in Fig. 14. Under these conditions, the easiest way to reverse the machine is to interchange the armature leads at the brushes although either the armature or the field leads may be interchanged at the terminals inside the field frame.

**The Goal of Boiler Designers** is to obtain the largest number of pounds of steam to each pound of metal in the boiler. The various studies and experiments have clearly indicated the advantage of the use of a longer flameway between the fuel bed and the end of the tubes, giving an opportunity for completing the gas reaction before the products of combustion enter the flues.—"Railway Age Gazette."

# Editorials

## The Foot of the Ladder

Now is the harvest time for the annual crop of college graduates. Among them are thousands who have acquired engineering degrees. To those of the latter who have had a particular interest in and have specially studied the various branches of science pertaining to power generation, these remarks and our cartoon this week are addressed.

Throughout the four or more years of your school and college preparation you have had a more or less distinct goal in view. From time to time since your childhood you may have changed your ideas as to what you intended to be, but now you have probably made a definite choice. And with this has come the roseate vision of *your* future.

Like the youth in the sketch, you may have imagined yourself the designer or the operator of a big plant, or may have dreamed of some other equally worthy accomplishment. To you whose eyes have been fixed on the top is coming a painful awakening when you realize that there are other rungs in the ladder, particularly at the bottom and that there is no royal road or aëroplane path to the top. You must climb every inch of the way, unless you have a "pull" that enables you to skip some of the lower rungs (and then you are more to be pitied than congratulated). That parenthetical statement is made advisedly; what you miss by not passing through the fundamental stages can never be made up to you in later experience.

Assume then that you are obliged to begin at "the foot of the ladder," and have taken a "job" in a power plant. One of the first duties assigned to you may be such as that being given to the chap in the picture: "Go polish the hand rails on number three." This seems much beneath you. You cannot quite reconcile it with your dreams and you may, and justly, inquire of yourself: "Is it for this I have taken a college course?"

Yes, and no! You did not need thermodynamics to know how to polish hand rails nor higher algebra to oil an engine, but because of your mental training those menial tasks will, or should, take on a greater significance. You understand better than the untrained helper that neatness in the appearance of an engine room is only an index of a corresponding orderliness in every other detail that makes for efficient power-plant operation.

You see beyond the oil holes and grease cups and have some conception of the relation between lubrication and the reduction of friction. You already know that the object of a cool bearing is not a matter of temperature but of preserving the rubbing surfaces in best condition, so that the heat units in the fuel, so expensively turned into force, are not needlessly wasted in friction work.

If you will but sense it, this period when you are engaged in the simplest of plant labor is one of rare opportunity to be observing and thinking over what you see. There is plenty of time for taking notes (mental, if not written), as to conditions as you find them, why they are as they are, how they might be improved.

Do not make the mistake of thinking that others have already worked out all the problems that there are to solve. History proves the contrary. Ten years ago the advances that have been made in that time were unbelievable. A decade before that steam engineering seemed to those then engaged in it as near the ultimate as it did at the end of that ten years or does now. No, there is very much yet to be done and, as experience has shown, every time perfection is in sight some revolutionary improvement renders all previous practice obsolete.

Further, it has been demonstrated that those whose discoveries and inventions have amounted to the most were those who did not despise the little things. The slow process of working up through the lower grades made them mindful of the importance of details, for every big thing is only the combination or result of a host of details.

So we would say to those just beginning, count nothing as too humble for your best endeavors. Be ready and willing to perform the most menial service required of you. If in no other way, it will be invaluable in character building such as will make possible of realization those dreams you dreamed under your study light.

Commencement, as the name for the exercises marking the completion of a college course, is no misnomer. Of a truth it was most wisely chosen if it helps to impress on the proud recipient of the diploma that passing his examinations was as nothing to what he must do before the world confers any honors.

## Another Coal-Saving Chemical?

Ever since the days of Kemkom there have been attempts, sincere and otherwise, to increase the heating value of fuel by a chemical admixture. Not so long ago engineers will remember that common salt or oxalic acid, disguised with coloring matter, was exploited to be mixed with ashes to be again used for fuel. The claims made were so extravagant as to be absurd, but, nevertheless, it had considerable publicity and sale. The latest announcement of an outbreak of this desire to get something for nothing appeared in the *New York Herald* under date of Apr. 29, in part as follows:

**A demonstration of a chemical composition recently perfected by a group of Canadian chemists was made yesterday in the boiler rooms of the Grand Central terminal. Officials of the New York Central R.R. were the spectators. The new chemical, a soluble crystal of secret composition, is poured over the coal, and, according to its discoverers, it increases the natural one part carbon and one part oxygen of the coal to one part carbon and two parts oxygen, the perfect state of combustion. The increased heat, it is declared, burns that portion of the coal which ordinarily is lost in the ashes.**

**From 10 to 20 per cent. of the coal used in boiler rooms and factories and 50 per cent. of that used in households can be saved by means of the composition, the originators say.**

A sample was procured by us for analysis (as in many

similar cases) in order to learn the truth. The following is the report of the chemist:

Nature of Material—Composed of colorless crystals and a black powder, the resulting color being very dark gray. All is soluble in water except the black powder.

| | |
|---|---|
| Loss on drying at 105 deg. C | 0.7 |
| Insoluble manganese dioxide ($MnO_2$) (black oxide of manganese) | 2.2 |
| Potassium chlorate ($KClO_3$) (chlorate of potash) | 64.4 |
| Undetermined and loss, mainly sodium chloride (NaCl) (common salt) | 32.7 |

It is the opinion of this laboratory that this material can have no practical value in saving fuel. The potassium chlorate will, on heating, liberate oxygen and promote combustion. The amount liberated, however, would not be enough to have any practical effect in saving the fuel when burned on a commercial scale. A pound of this substance would yield about as much oxygen as would be contained in from 15 to 20 cu.ft. of air, and as air costs nothing, it is much more logical to use the oxygen in the air for combustion than to use that from the powder.

In view of the foregoing, it is no surprise to learn that the results of two tests by the New York Central failed to verify the claims of the promoters. The absurdity of the whole thing is so apparent that further comment seems superfluous.

## Encouragement for the Oil Engine

The greatest handicap to the general adoption of the oil engine in this country has not been its comparatively high first cost nor its mechanical difficulties, but the continually increasing price of fuel oil. Therefore, it is gratifying that the recent action of one of the great oil-refining interests may result in reducing the price of that commodity to a point where the high efficiency of the oil engine may be realized to advantage.

This possibility has been brought about by the decision not to purchase crude oil below eighteen degrees Baumé (0.948 specific gravity) for refining purposes. California and Mexico produce large quantities of crude oil of asphaltum base, high in sulphur but containing little gasoline or the lighter distillates, that evidently is considered as offering insufficient pecuniary reward for distillation. In California alone, about seven hundred thousand barrels of such oil is produced each month. Engines have already been developed to utilize these oils and further development seems assured.

Gratifying though this announcement may be for the oil engine, there remains a fact that may retard its general adoption; a fact that makes it difficult to reconcile the abandonment of refining heavy crude oils. Crude oils rich in gasoline and light distillates make an excellent fuel oil after the gasoline and light distillates have been removed, and if the profit in refining lies in the amount of gasoline that can be extracted, it would seem that the residue could be marketed at a correspondingly low price for use in oil engines. Instead of this, the price of the "fuel oil" residue has mounted as steadily and as rapidly as has the price of gasoline, the explanation being that the residue was too valuable to sell as such and that further distilling was a pecuniary necessity, the profit from the heavier byproducts being such as to fix the price of the fuel oil.

Logically, this should place a comparatively high value on the heavy asphaltum-base oils which it is claimed it will not pay to refine. The heavier byproducts could be easily distilled and the asphalt should find a ready market. It would appear, then, that the oil engine has been discriminated against ever since its advent, and that even now, when it would seem about to receive fairer treatment, the respite may be but temporary. The value of the heavy distillates of petroleum may suddenly increase in value—an increase that may occur without any apparent increase in demand or in curtailment of supply. Some equitable and binding agreement between the refinery and the oil engine is demanded by the economic situation of the day.

## Indicator Diagrams

The first letter on the opposite page refers to a Green-Corliss engine which was erected in a certain city twenty-seven years ago, and had never been indicated until last March, when the diagrams shown were taken. The engineer made all his valve adjustments entirely by sound.

This engineer says he is a busy man and does not have time to read engineering papers or books. How successfully he has applied his native skill is evident and creditable, but it is apparent that the performance of the engine could be improved and less steam used.

As a man's handiwork reflects his predominant characteristics, let us consider these as characteristic "indicator diagrams" of the engineer as well as his engine. Lead or admission into an engineering society or association should have been earlier; more lead would improve both the head (think) and the crank (work) end. This is most noticeable at the head end, as a higher steam line or achievement nearer to that possible (boiler pressure) should have been attained. The steam or energy line does not hold up well, and is carried further before cutting off than would have been necessary had not the pressure been wire-drawn or throttled.

The point of cutoff is not sharp and well defined; the dashpot (or dash) seems faulty; the expansion line is not as good as it should be. The exhaust would be more free and the back pressure or resistance be less if adjustments were made. With a little more steam (knowledge) compressed at the head end, the cushion would be better and the machine would operate more smoothly with fewer shocks. All these adjustments could be easily accomplished by a little reading and mixing in the association. Lead could be acquired with high achievement, and good expansion by such improved head work.

The crank or work end is better developed, and is more consistent, although improvement at the head would also influence the crank. Then the performance of this human machine would be excellent.

Suppose that you are dissatisfied with POWER. Suppose your butcher, your baker and the candlestick maker do not meet with your approval. In the latter supposition you take quick action; you tell them so. POWER can only take the standpoint that you are satisfied with it, when you say nothing. This is your paper as well as ours. Let us have your frank criticism; in return we will publish the paper that *you* want.

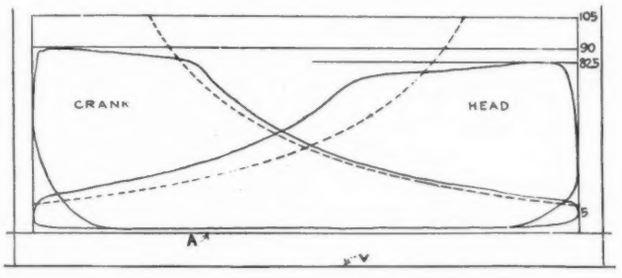
In all probability there would be less discontent by power-plant employees if the management would take them into its confidence as to the cost of upkeep, depreciation and general running expenses. A general understanding that all is not profit outside the fuel and labor charges should have a wider dissemination.

# Correspondence

## Valve Setting by Ear

Considering all the circumstances, the indicator diagram herewith is somewhat remarkable. It was taken from a Green-Corliss engine, 27 years old, which had never been indicated before. The same man who set the engine up is now running it. He never saw an indicator from that time until one was applied recently to take this diagram. In the meantime, he has set his valves entirely by sound, and in the light of that fact the diagrams from the two ends are well balanced and the events not at all badly timed.

The engine has a single cylinder, 16 in. in diameter,




Diagrams from Engine with Valves Set by Sound

by 36-in. stroke and runs at 70 r.p.m., using steam at 105-lb. boiler pressure and exhausting to the atmosphere. The scale of the spring used in the indicator was 60 lb. The diagrams integrated show a total of 247.96 hp., the head end giving 130.12 hp. and the crank end 117.84 hp., so that neither is far from the average of 123.98 hp.

H. L. Smith.

New York City.

## Lead Boiler Gaskets

Mr. Hawkins' letter in the issue of April 28, page 604, recalls my experience with such gaskets.

The plant had three O'Brien safety water-tube boilers of 535 hp. each. Lead gaskets, similar to the ones described by Mr. Hawkins, were made and used for several years with good results except that many of them would leak every time a boiler was allowed to cool down. However, most of the leaks would take up when the boiler was steamed up again, and the ones that failed were stopped by tightening up.

Taking the cost, etc., into consideration, they were satisfactory until we began using boiler graphite; then our troubles started. One man was kept busy stopping leaks, and frequently a boiler would have to be cut out when they could not be stopped.

On close inspection I found that some kind of chemical action was decomposing the lead in places.

The only cause to which I could lay this trouble was the graphite, and as excellent results were obtained from its use in the boilers, the lead was discontinued and jointless asbestos gaskets were found satisfactory.

These gaskets will last almost indefinitely when they are not disturbed, and they can be taken out and put back from 10 to 15 times, if given a liberal coating of flake graphite. It was necessary to use a new lead gasket every time a plate was removed, and to renew them every three or four months whether the plates were removed for other purposes or not.

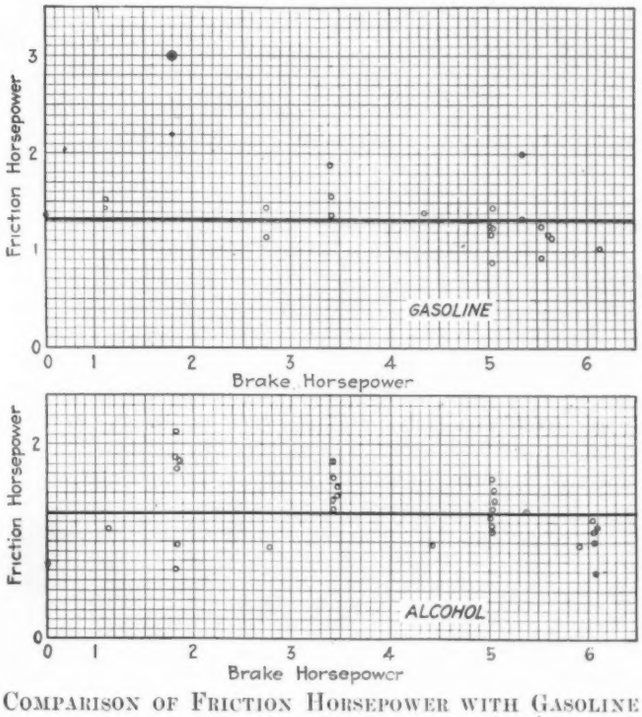
W. A. Johnston.

Pine Bluff, Ark.

## Friction Horsepower

Robert Thurston was the man who affirmed that the frictional horsepower of a steam engine is practically constant at all loads. It is so considered in most textbooks, but it does not appear to be as generally known in relation to gas or gasoline engines, although the writer can see no reason why one should judge otherwise, provided the running conditions are right.

After comparing various test reports the rule is shown




Comparison of Friction Horsepower with Gasoline and Alcohol

to hold as well for internal-combustion engines. Papers by C. H. Roberston, in the *Transactions* of the A. S. M. E., Vol. 21, page 396, and Vol. 22, page 612, show this to be true for a 125-hp. gas engine.

The points on the diagram herewith are plotted from Bulletin 191 of the United States Department of Agriculture. Gasoline and alcohol were burned in the same

engine, and a comparison of results should therefore be interesting. With gasoline, the average energy consumed by friction was 1.317 hp., whereas with alcohol 1.305 hp. was consumed.

One test with gasoline gives a frictional horsepower of three, which is so obviously wrong that it was not considered by the writer in averaging the power absorbed by the engine through friction. It is marked by a double circle.

One can, therefore, rightfully conclude that with normal speed, lubrication and water circulation, the friction horsepower of any internal-combustion engine should be fairly constant regardless of fuel and load.

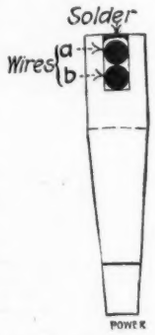
W. F. SCHAPHORST.

New York City.

## A Centrifugal Effect

In one form of single-phase induction motor, a centrifugal device opens a switch that normally is used to close an auxiliary winding which enables the motor to start three-phase from a split-phase starter. In another form of induction motor, centrifugal effect is utilized for moving a ring that short-circuits the commutator bars at a certain speed above which the machine operates as a squirrel-cage induction motor. It is rarely, however, that centrifugal force is accidentally applied to make operative a motor that otherwise would not be.

A 20-hp., 500-volt, bipolar motor was belted to a small compressor that stored a tank used for charging air-brake reservoirs on electric cars. At starting and up to about one-half speed, a vicious spark traveled around the commutator, indicating an open-circuited winding. Above a certain speed, sparking ceased. Investigation showed the condition indicated in the accompanying sketch.




COMMUTATOR EAR

Each commutator ear had two coil leads connected to it. In the one that was the seat of trouble, the bottom conductor *b* had good soldered contact with the ear; the top conductor *a*, however, was suspended between the bottom conductor and a solder cap still intact in the upper part of the ear and without making contact with either. At all speeds below a certain value, this condition obtained; but above this speed, centrifugal force threw conductor *a* outward until it made contact with the soldered cap in the slot; all sparking then ceased as there was no open circuit.

J. A. HORTON.

Schenectady, N. Y.

## Feed Heating by Live Steam

In his excellent article, in the Apr. 28 issue, Mr. Braucher argues in favor of live-steam heating of the feed water on the grounds that hot water takes up heat more readily than cold. This is undoubtedly true, but it is possible to carry the explanation still further.

The heat of the fuel is transferred to the water in the boiler largely by conduction and convection. Particles of water in contact with the metal surfaces are heated by conduction; they then diffuse among the other particles and cause the whole to become heated by convection.

The transfer of heat from the metal surfaces to the water depends largely upon the velocity with which the water flows over the metal; the greater the number of particles brought into contact with the metal in a given time, the greater will be the amount of heat carried away, assuming a definite difference of temperature between the water side and the fire side of the plate. But the rapidity of motion is not the only consideration; diffusion or the spontaneous mingling of the molecules is also a factor even while the water is still and without currents.

Now, the ease with which the molecules of a liquid will move over and among the other molecules of the same liquid depends upon its viscosity, which in reality is a measure of the internal friction of the molecules. In a material like tar, the viscosity at ordinary temperatures is very high; that is, the friction of the molecules is so great that the tar flows sluggishly. On the other hand, an oil like gasoline has a low viscosity, so that it flows easily and rapidly.

A viscous liquid, if heated, becomes less viscous and flows more readily. This fact has a practical application in some plants that use crude oil as fuel. At low temperatures certain crude oils are so viscous that they will not flow through pipes and can be pumped only by the expenditure of considerable energy. To overcome this drawback, steam coils are inserted around the suction pipe in the oil tank. The heat of the steam so lowers the viscosity of the oil that it can be pumped readily.

What is true of tar is equally true of water. The viscosity of water at ordinary temperatures is greater than that of boiling water, which means that the molecules of boiling water meet with less resistance in moving over one another than do the molecules of cold water. Here, then, is a plausible explanation of the gain obtained by heating feed water with live steam. The heat derived from the steam increases the temperature of the feed and at the same time lowers its viscosity. The result is that the convection of heat both by circulation and by diffusion is made more rapid, because the molecules slide more easily over one another.

In corroboration of this may be cited experiments on the rate of heat transmission through tubes to water flowing through them, as in surface condensers, which were carried out in the laboratory of Owens College (Great Britain). The results of these experiments showed definitely that the amount of heat transmitted in a given time per unit area of heating surface was appreciably increased by heating the water. Some of the values from these experiments are tabulated herewith. It is interesting, first of all, that the velocity of the water was the same in all three experiments. The ratio of the viscosity to the density of the water, however, decreased markedly as the temperature of the metal surface was raised and the water was more highly heated. As the change of density is small with the rise of temperature, the rate of decrease of viscosity is practically that indicated by these ratios.

RESULTS OF EXPERIMENTS ON HEAT TRANSMISSION

| Temperatures, Deg. Fahr. | | | | | Mean Value of Viscosity / Density |
|---|---|---|---|---|---|
| Surface | Cooling Water Initial | Cooling Water Final | Rise of Temperature | Velocity of Flow Ft. per Sec. | for Cooling Water |
| 125.0 | 99.5 | 107.3 | 7.8 | 9.7 | 0.0000071 |
| 108.6 | 83.0 | 90.4 | 7.4 | 9.7 | 0.0000086 |
| 82.8 | 57.3 | 64.0 | 6.7 | 9.7 | 0.0000116 |

The range of temperature—that is, the difference be-

tween the initial temperature of the water and the temperature of the metal surface—is practically the same in the three cases. But with the higher initial temperature of the water, the rise of temperature was 7.8 deg. as compared with 6.7 deg. with the lower initial temperature. As the heat transmitted is proportional to the temperature produced, the increase in the amount of heat transmitted in the first case is

$$(7.8 - 6.7) \div 6.7 = 16 \textit{ per cent.}$$

greater than in the last case.

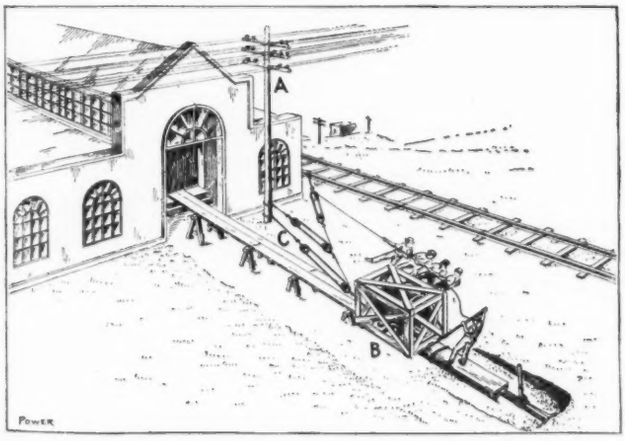
The case of a steam boiler is similar, in that the water moving over the plate or tube surfaces has its temperature raised by the heat of the hot gases on the other side. It is reasonable to assume, therefore, that the increased temperature causes decreased viscosity and results in a more rapid transmission of heat from gases to water. In other words, the gain derived from heating feed water with live steam is due to the water being brought into a condition in which it will receive heat more readily and transmit it more easily and quickly to the water in other parts of the boiler.

R. T. Strohm.

Scranton, Penn.

## Heavy Hauling with Block and Fall

Recently the writer had to unload a 300-kw. rotary converter from a coal car and move it about 125 ft. across the power-station lawn and then up an incline of 3½ ft. in 30 ft. into the engine room. This converter was shipped in two pieces, crated on skids, the frame, base and polepiece or field coils being in one crate and




Showing Arrangement of Tackle

the armature in another. The writer had only four men to help him and two screw jacks and three sets of ¾-in. rope falls and plenty of plank and blocking. The sketch will explain how we were able to do the job.

A telegraph pole *A* is located just beyond the door into which I wished to put the machine, and *B* represents the load. First we hitched the working or stationary block of one set of double-rope falls to the load *B* and after separating the blocks as far as the hauling line would permit, made the other block fast to the dead line *C*, the other end of which was fastened to *A*. The traveling end of another set of double-rope falls was made fast also at *A*, and with a catspaw hitch we fastened the other block to the hauling line of set No. 1. The traveling end or block of a third set of double-rope falls was made fast to the end of the drag line of set No. 2, and the other end fastened to a rail of one of the side tracks leading into the car barn. The rig was then ready to test. The men took up the slack and the writer put a bar behind the armature and by taking short nips could help the men on the start and before long we had the machine where it had to be turned to go into the station. It required considerable changing of hitches and shortening up on the dead line and drag lines, but we got the armature where we wanted it.

After we got the machines turned and headed up the inclined track into the station another problem presented itself. That was to hold the load while we changed the hitches, and after some thinking we adopted the following method. A hole was dug near the machine and on the same slope as the track into the station. One short plank was placed against the opposite bank of the hole. This was for an abutment for the lever jack. Then with a few pieces of blocking between the load and the jack we could get the strain on the jack and hold the load until we could get the falls rearranged ready to move along another 10 ft. or so. The writer cannot recommend this rig for speed, but where there is but little help and no crane it saves a lot of back ache and sweat and will enable a very few men to do the work of four or five times their number.

W. E. Chandler.

North Adams, Mass.

## Draft Gage

My experience is that the draft gage leads all the rest of the boiler-room instruments in importance, at least when burning liquid fuel under variable load.

With liquid fuel, the steam pressure controls the oil pump, which makes it possible to reduce or increase the volume of fire under the boiler almost instantly. There is no bed of hot coal to check the admission of cold air to the hot shell in the event of the fires being suddenly reduced. It is, therefore, of the utmost importance that the draft be kept under more rigid control than in coal-burning plants.

Operating with damper regulators obviates much of the loss occasioned through load fluctuations, but it is almost impossible to set the damper regulators unless draft gages are used in this connection. One on each boiler will save the cost of the gage in a short time. For instance, in our plant when both boilers were in use, the draft gages read the same, but when only one was on, the gage on the other registered 0.1 in. The dampers were found to be tight. Finally, it was discovered that the wall dividing the boilers was cracked, thereby allowing cold air to flow not only through the boiler out of service, but also through the one under fire. Any engineer will appreciate what the loss might have been.

Whenever it is noticed that the draft gages are varying, the first procedure is not to reset the dampers without first investigating the cause of the variations. A little judicious "nosing around" will generally disclose cracks and air leaks. The application of a little asbestos cement mixed with liquid silicate of soda to such cracks will usually allow the gages to read the same without any adjustment whatever.

The writer adjusts the dampers to give a good working

percentage of $CO_2$ for every position, using an Orsat for checking. By noting the oil pressure at the time the checking is done, it is easy to so set the dampers that there will be given an almost uniform condition of combustion in the boilers for any given rate.

The draft gage is one of the cheapest instruments to install and is, in the writer's opinion, the most important.

WILLIAM PLAISTED.

Redondo Beach, Calif.

## Accident to a Blowoff Valve

The extract from a paper by S. F. Jeter, on "Boiler Inspections," on page 649, May 5, mentions the blowoff valve as a fruitful source of danger, particularly when placed in a closely confined space. This recalls an experience of mine some years ago.

The boiler (of which I had just taken charge) had a brass stop-cock on the blowoff pipe—one of those with the plug cast hollow to save brass. Between it and the boiler was an asbestos-packed cock.

The operating space, about 3x3 ft., was inclosed on three sides, and on the fourth, the means of exit was either over or under the blow-off pipe. Using kerosene brought the scale down very fast, so that when the blow-off was opened, only a little steam and water issued from the pipe. I closed the cock, to work on it later when I had more time.

Soon after the cock was closed, there was a rattling sound in the pipe, followed by a loud report, and the brass plug was smashed. Fortunately, I had placed a wrench in position on the asbestos-packed cock and was able to close it.

An examination of the brass cock showed that the hollow plug had been crushed in as if struck with a hammer. My theory is that closing the brass cock caused a vacuum in the pipe, aiding the steam pressure to force the obstruction and causing water-hammer.

BASIL COPPING.

Kankakee, Ill.

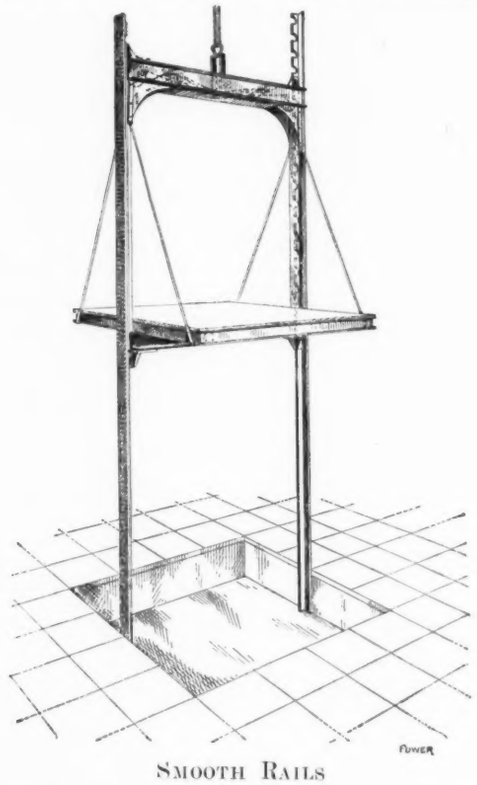
## Safety Device Could Not Hold

The writer was called to look over an elevator, the safety catches of which had failed to work on the previous day. It was condemned by the inspector, ordered overhauled and put in safe working order.

The car was lowered to the basement, a 30-in. prop placed under the platform in a vertical position, and the cable slackened enough to allow about 1-ft. drop. The stick was then knocked out from under the platform, and the car dropped about 1 in. It hung suspended by the safety catches with the cable slack. The trial was repeated with the same result.

We were told a stick 18 in. long had been used by the inspector so the test was repeated with a prop that long, but the catches failed as on the previous day. What was wrong? The car was run up and the guide rail examined. It was found that smooth rails had been used on each side at the bottom up to a point just above the beam of the car. While the car was in the basement the rails could not be seen. The smooth rails were taken off, and toothed rails put on. These old rails had been in use for many years, and had not been noticed until the inspector, for lack of a longer stick, had picked up the short one by chance. Had he followed the custom of other inspectors by testing at one of the upper floors the safety device would have acted.

Some elevators have smooth guide rails and friction clutches to grip them in case the cable breaks; in others, even a rough, corrugated, eccentric-shaped, safety gripping device is worn away from lack of lubrication, and



SMOOTH RAILS

is not capable of the least resistance to prevent a car falling to the basement. Cars should be tested each day, the safeties kept in constant operating condition and all defects discovered if possible before the accidents occur.

Cambridge, Mass. R. A. CULTRA.

## Pump-Packing Troubles

I had considerable trouble with the water-end packing on a small boiler-feed pump of the plunger type. In the daytime, when the pump handled return water at about 180 deg., there was no difficulty, but during the night, when cold water from the city mains was used, the pump cooled and the glands leaked badly. The night man would tighten them up in the evening and slack them out in the morning. This was sometimes forgotten in the morning, and the hot water would expand the packing and cause excessive friction and wear.

To overcome this, live steam was piped to the receiver of the pump and throttled just enough to keep the temperature about the same as during the day shift. This was easily done, because the demand for water at night is practically constant. After making this change the plunger and piston-rod packing lasted almost twice as long and reduced the friction considerably; this also prevented excessive loss of water.

A. R. KUMMERER.

Hazleton, Penn.

## Value of Laboratory Coal Testing

There are some important features affecting the value of laboratory tests on coal. A proximate analysis in which moisture, volatile combustible matter, fixed carbon and ash are determined by methods that are more expeditious than accurate, should only be relied upon when the general character of the coal has been previously established by more exact and rigorous methods.

In any case, the chemical analyses only establish the fact that the coal contains the elements hydrogen, carbon, sulphur and other substances that are either inert or prejudicial. The hydrogen contained may not benefit in proportion to its percentage, for the hydrogen and oxygen present react, resulting in the elimination of hydrogen with the formation of water vapor, which absorbs heat, thus entailing a loss.

The proximate analysis does not indicate such a condition which can only be obtained by a strict quantitative analysis. Serious error may arise from some wrong procedure, either in securing the sample or some detail that would have important influence on the results.

Obtaining samples is too often entrusted to someone lacking practical judgment; while the sample itself may be representative in general, certain physical characteristics are lacking without which the results are practically worthless.

In collecting samples a man should note when a particular invoice is very much finer than the regular run. The chemist would never surmise such a condition from his results if his attention had not been directed to it by a note or statement. It is highly desirable to have the chief engineer and the chemist coöperate in coal sampling and testing.

The engineer and his staff in their experience acquire a lot of knowledge in regard to the peculiarities of coal, and if there is a mutual interchange between the boiler room and the laboratory there is no doubt that much valuable data would be secured.

The matter of analyzing the ashes is important, for often it shows the fact that considerable coal is going to the ash dump when not apparent by observation.

T. H. Reardon.

Pittsfield, Mass.

[See also the editorial on coal analysis which appeared Apr. 14 and the letter by C. J. Barton on page 640, May 5, which are along the same general lines.—Editor.]

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In reply to C. J. Barton's letter, in the issue of May 5, under the above caption, I will say that too many engineers and others underestimate the true value of the laboratory test when properly done by a competent man. The only way to buy coal is on the B.t.u. basis; then you pay for what you get and not for what someone else says you get.

In making our contract for coal every year we specify that each pound must contain so many B.t.u. For instance, last year the guarantee read 13,400 B.t.u. and 8 per cent. ash, at $2.20, and the ashes hauled away from the plant. This last item, prior to making contracts stipulating the B.t.u. and ash, cost us 6c. for each ton of coal burned, which would make our cost price $2.14 per ton. The way we arrive at the final figures is this: Multiply the actual B.t.u. by the cost per ton and divide by the number of B.t.u. guaranteed.

Supposing a sample drops to 11,500, which is often the case, it would work out thus:

$$11{,}500 \times 2.14 \div 13{,}500 = \$1.836$$

instead of $2.14, or a saving of over 30c. per ton, or a lump sum of $61.20, in one month, which is no small saving, besides the satisfaction of knowing that we pay for only what we get. The following is the form on which the analyses are reported:

LABORATORY OF W. J. RATTLE & SON
33 Commercial Bank Building
Cleveland, O. 7-1-13

For.....
Sample of Coal Received 6-28-13.
B. L.....
Boat.....
Tons.....
Dock.....

| | Per Cent. | |
|---|---|---|
| Moisture | 1 | 37 |
| Volatile combustible matter | | |
| Fixed carbon | | |
| Ash | 13 | 17 |
| Sulphur | | |
| Phosphorous | | |

Calorimeter Test

B.t.u. (dried at 212° F.) ..... 13,038

Analysis by William Rattle

Now the ash problem will work out similarly, only in a smaller ratio. A man must keep abreast of the times, but to do this, it is not necessary to adopt any fads or fancies. There are some things that are absolutely necessary today which did not exist 15 or 20 years ago. All owners of isolated plants look for better results than they did a few years ago, for they are frequently told that they can buy current cheaper than they can manufacture it. One way to keep the central station out is to put your plant on as economical a basis as possible and buying coal on the B.t.u. basis is another.

O. Newton.

Cleveland, Ohio.

## Gage Hand Jack

The hand jack illustrated is an improvement over the various types now on the market, its special feature being that the screw cannot be clogged with dust and dirt, it has no sharp corners, and, therefore, can be carried in the pocket.

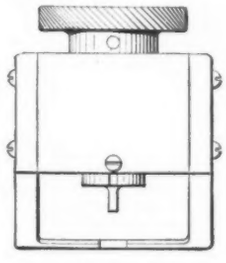


Fig. 1.

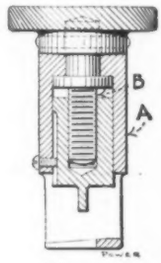



Fig. 2.

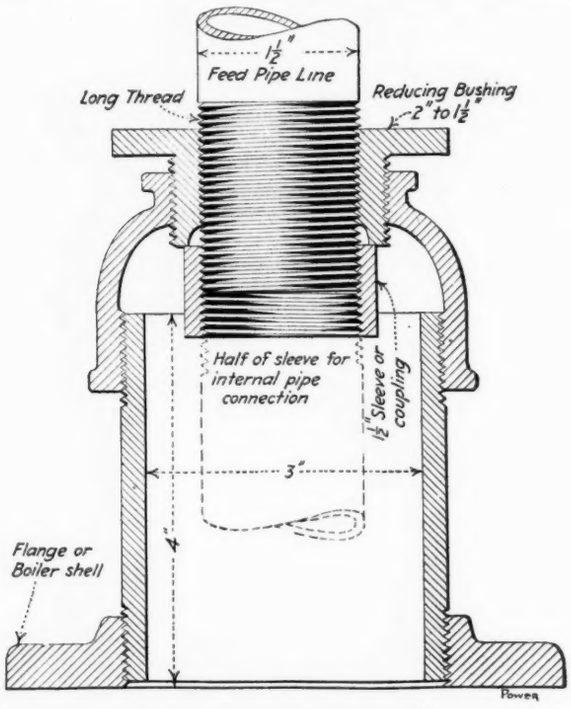
Fig. 1 is a side view and Fig. 2 a section, showing how the sleeve *A* protects the feed screw *B*.

Ernest Schwartz.

Bronx, New York City.

## Troublesome Pipes

Feed and blowoff pipes often fail at their junction with the boiler. The method of connecting shown has proved




FEED-PIPE CONNECTION

satisfactory. The fittings used are so familiar that an extended description is unnecessary.

New Orleans, La. GEORGE SCHWESSINGER.

## Cheap Labor?

Many columns have been devoted to boiler firing, and many are the good suggestions offered and scientifically explained, but I regret that they are not read and studied by the men who handle the shovel. To make this possible they would have to be printed in a foreign language, for most of the coal in this city is handled by cheap foreign labor.

To keep the payroll as low as possible seems to the proprietor the most economical, but it is not so. Where a new plant is installed on a guaranteed evaporation of water per pound of coal, the contractor runs his tests with first-class firemen, the best that can be had (at times engineers are engaged to fire the test). After the test is over and the owner puts in his 12 hr. and $2 a day men, the coal cost goes up, as do many other accounts. Yet he will still say that it is out of the question to pay competent men $3 or $3.50 per day to get the best rating of his plant, and complains to the chief engineer about the coal used.

The engineer knows it is useless to try to educate such firemen. He can discharge them, but the pay prevents his getting another class of men more competent. The payroll must be kept at the lowest point, and the owner thinks he is saving money. Central stations are gaining through this particular cause. It is time for the isolated-plant owner to wake up, take his engineer into his confidence, and find out how the plant can be conducted to show a big profit over the central-station figures. This has been demonstrated many times by owners who have placed their confidence in the engineer and given him a free hand to make it possible.

New York City. J. C. SCHENCK.

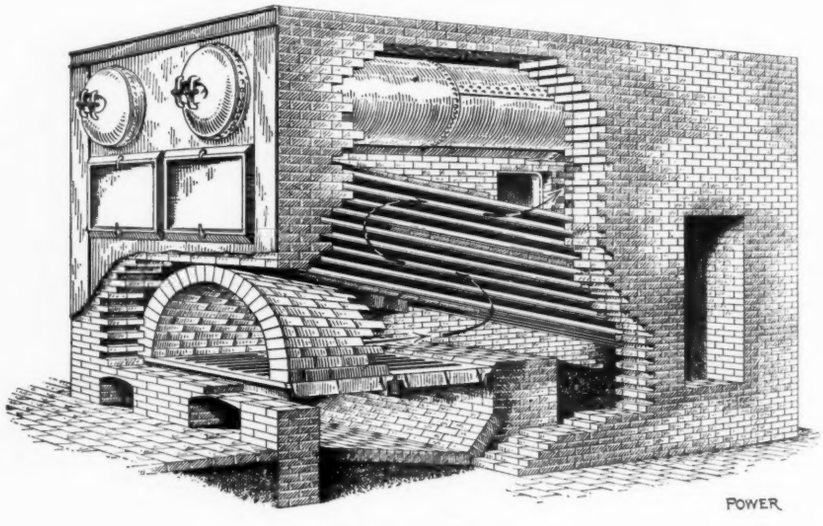
## Fatal Tube Failure

An eyewitness gives the following description of a boiler-tube failure occurring nine years ago which cost the lives of four men. It never reached the press as the employees were pledged to secrecy on pain of dismissal.

The boiler was a so called high-pressure, water-tube, and was used for testing purposes. Steam for testing was often carried as high as 500 lb. to the square inch. When not in demand for this service it was used for ordinary steam making in connection with a battery of other boilers. The high furnace temperature incidental to such pressure and other severe conditions caused considerable trouble by overheating the tubes, several having been replaced because of signs of distress. To protect that part of the bottom row of tubes directly above the fire, a firebrick arch was built over the grate-bar space. This form of furnace proved disastrous, partly because no chance was had to watch the tubes while in operation.

In a short time after the test boiler had been cut off the line to run the steam pressure up to 400 lb., a bottom tube was ruptured. Just what the pressure was is not known. A subsequent examination showed that the tube had been badly bagged, probably for some time, as the metal was stretched extremely thin at the edges, and it had opened out almost flat for a distance of about 2 ft. The boiler front and furnace settings were almost completely wrecked.

The sketch will give an idea of how the arch was placed in the furnace. It would seem that after the brickwork got thoroughly hot the arch was not much protection.




ARCH IN PLACE

Philadelphia, Penn. EDWARD T. BINNS.

## Unusual Construction and Wear

The foreman of our machine shop was sent to an engine plant to make repairs. The engine was an 18x42-in. Corliss, which had been running almost continuously for 10 years. The illustration shows the piston, the piston rod and the crosshead. The piston was 4½ in. and fitted with a single sectional packing ring. Each section of the ring was supported by a coil spring contained in a socket cored in the bull ring, holding it against the cylinder bore. The crosshead was bored out in the hub, not threaded, to 2⅜ in. diameter.

The piston rod was fastened with the nut *C*, and nut *A* screwed on the end. The three setscrews *B* screwed into the hub of the crosshead and against the nut *A* were undoubtedly meant for the purpose of alignment. On taking out the piston, it was found that the bore of the cylinder, although perfectly round, had worn in a regular taper from 18 in. at the center to $18\frac{1}{16}$ in. at either end, as shown, and also that a depression had been worn under the point of each setscrew. This led to the conclusion that one of the nuts, either *C* or *A*, must have become loosened, which caused the setscrews to wear the nut *A*, as shown in the detail. It could then move in any direction, allowing the piston to tilt and wear the cylinder as mentioned. The satisfactory method is to screw the rod directly into the crosshead and then lock with the nut *C*.




Detail of the Locknut

C. R. Courtenay.

Watertown, N. Y.

## An Interesting Steam-Engine Breakdown

The writer recently investigated the breakdown of a horizontal compound engine. The engine, mounted on the top of a locomotive-type boiler and fitted with a superheater and jet condenser, had been running for the greater part of the day under apparently normal conditions.

The first warning was severe hammering in the cylinders, and before the engine could be stopped the back low-pressure cylinder cover was smashed, both pistons were broken, the end of the piston rod was broken off and the cotter at the crosshead end of the rod was sheared through.

Such an accident is characteristic of water in the cylinder, but the question was, how could it get there? The condenser was located about 3 ft. below the center line of the cylinders and the air pump about 1 ft. lower than the condenser. The engine was coupled to the same shaft as a waterwheel to take the load at times of insufficient water. At this time the stream was in flood and it is probable that the waterwheel was taking more than its usual share of the load. The conclusion was that the engine was being pulled around and the low-pressure cylinder acted as a pump and produced a better vacuum than the condenser, lifting the water from the condenser.

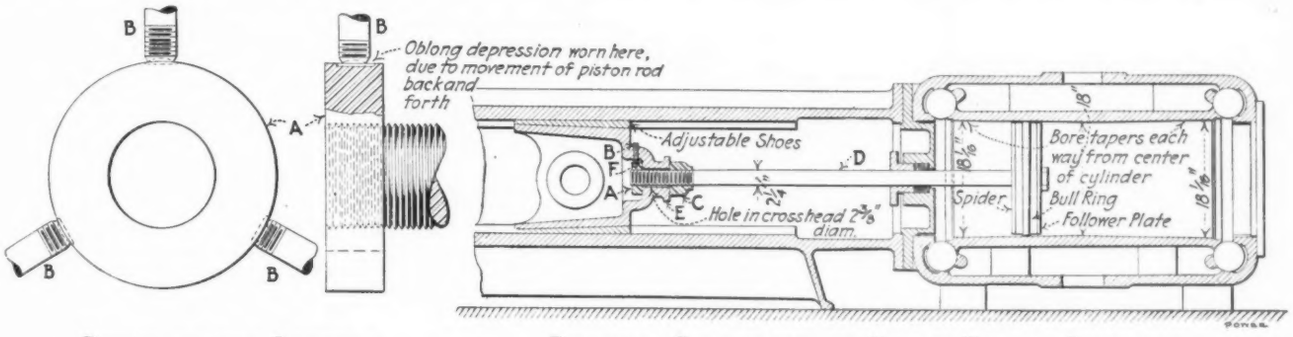
There is an element of risk in coupling a waterwheel rigidly rather than through a free wheel. Such accidents would probably be prevented by placing the condenser as low as possible relative to the cylinder, fitting a nonreturn valve in the line and a float to break the vacuum as soon as the water rose above its normal level in the condenser.

C. H. Williams.

Manchester, England.

## A Condensing-Plant Suggestion

A large number of plants in the Central states, where the rivers vary in height as much as 40 ft., have the condensing equipment located in pits several feet below the engine-room floor. This allows of water being furnished to the circulating pumps by gravity, but furnishes a more or less difficult proposition in disposing of the condensate, which is generally handled by single-stage centrifugal pumps. These pumps elevate the water to the surface into feed-water heaters.




Peculiar Connection of Piston Rod to Crosshead

The total head, including friction, is in many instances in excess of 50 ft. A pump handling water against such a head with a 28 or 29-in. vacuum must be at all times in almost perfect shape, as a slight leak at the suction side will suffice to stop the pumping action. Then it becomes quite a job to restart the water toward the heater. In the meantime the condenser is filling and the engineer is expecting a crash if a slug of water reaches the dry-vacuum pump. (The pumps in such installations are usually placed on the engine-room floor.) Water mixed with air in alternate slugs has no respect for the proverbial 34.5 ft. The air in the water expanding will cause the latter to be lifted several feet in excess of the theoretical maximum suction height. The dry-air pump is not free from danger of flooding, because it is over 34 ft. above the condenser.

In installations of this kind there should always be provided an emergency low-head discharge outlet near the pump. This outlet, provided with a seal, can be opened into the pit and temporarily relieve the condenser until the trouble is located.

Louisville, Ky. John F. Hurst.

# Engineers' Study Course

## Elementary Mechanics--XI

LAST LESSON'S ANSWERS

46. The pressure on the part of the boiler head supported by the stay is

$$6 \times 9 \times 120 = 6480 \text{ lb.}$$

and this force acts at an angle of 90 deg. to the head. The sides of the triangle $ABCA$ (see Fig. 42) represent the

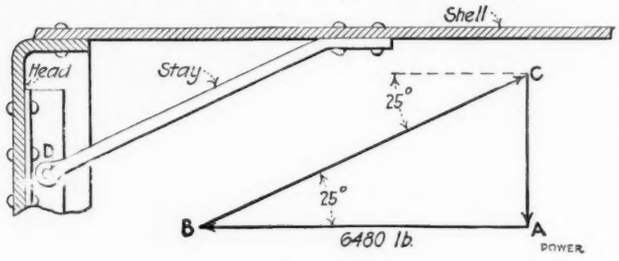



FIG. 42.

three forces acting at the point $D$ where the stay is fastened to the head of the boiler. If the stay was horizontal the pull would be 6480 lb., but since the stay makes an angle with the shell the pull becomes correspondingly greater. Let the side $AB$ equal 6480 lb., or the force tending to blow out the 6x9-in. piece of the boiler head. The side $BC$ will give the load on the stay and the side $AC$ will represent the force tending to shear the rivets.

$$BC = \frac{BA}{cos\ 25\ deg.} = \frac{6480}{0.906} = 7152$$

Therefore, the pull on the stay-bolt is 7152 lb.

47. Let the weight $W$ be placed at the point $E$, midway between the points $A$ and $B$ (see Fig. 43). A vertical line drawn through the point $E$ will bisect the line $AC$ at the point $D$. The vertical force acting at the point $A$ and at the point $B$ will equal $\frac{1}{2}$ $W$, since $W$ is located at the center of the line $AB$. Consider the point $A$ as a free body, as shown in Fig. 43. The side $MN$ of the triangle $MNOM$ is drawn horizontal and represents the thrust in the strut $AB$. The side $ON$ is drawn vertical and equals $\frac{1}{2}$ $W$ while the side $OM$ is drawn parallel to $AC$ and represents the pull in the tie-rod $AC$. The angle $OMN = 30$ deg. Therefore, the side $OM$ or

$$T = \frac{\frac{1}{2} W}{sin\ 30\ deg.} = \frac{500}{0.5} = 1000 \text{ lb.}$$

Likewise the side $MN$ or

$$P = 1000 \times cos\ 30\ deg. = 1000 \times 0.866 = 866 \text{ lb.}$$

Hence the tension in the tie-rod is 1000 lb., which is just one-half of what it was when the weight $W$ was placed at the end of the bar $AB$.

48. There are three forces acting at the point $B$, namely, the vertical force $\frac{1}{2}$ $W$, the horizontal pressure in the strut or 866 lb., and the reaction of the pin $B$. The resultant of the horizontal pressure in the strut and the vertical load at the point $B$ is the pressure acting on the pin $B$. Construct the parallelogram $BRSKB$ (see Fig. 43) with the side $BR = 866$ lb., and the side $BK = 500$ lb. The diagonal $BS$ gives the direction and magnitude of the pressure acting on the pin $B$. Thus

$$BS^2 = RS^2 + BR^2$$
$$= 500^2 + 866^2 \text{ (since } RS = BK = \tfrac{1}{2} W)$$
$$= 1{,}000{,}000$$

or

$$BS = 1000 \text{ lb.}$$

Also the $sin\ x = \frac{500}{1000} = 0.5$, or angle $x = 30$ deg. Therefore, if the diagonal $BS$ is extended backward it will pass through the point $D$ since the angle $DBE = 30$ deg. = the angle $x$. It is to be noted that the point $D$ is the point of intersection of the line of action of the weight $W$ and the line of action of the pull in the tie-rod $AC$. Hence the direction of the pressure on the pin $B$ might have been determined directly by drawing a line through the points $D$ and $B$, as explained in Lesson V, under the solution of problem 20.

Still another method of finding the magnitude of this pressure is as follows: Construct the parallelogram $DHFGD$, letting the diagonal $DF$ = the weight $W$ (to scale). Then the side $DH$ represents the tension in the tie-rod $AC$, and the side $DC$ represents the pressure on the pin $B$. It is evident that the triangle $DFHD$ has all its sides equal since all its angles are equal, or $DH = DG = DF = 1000$. Therefore both the tension in the tie-rod and the pressure on the pin $B$ are equal to 1000 lb. The force producing equilibrium at the point $B$ is

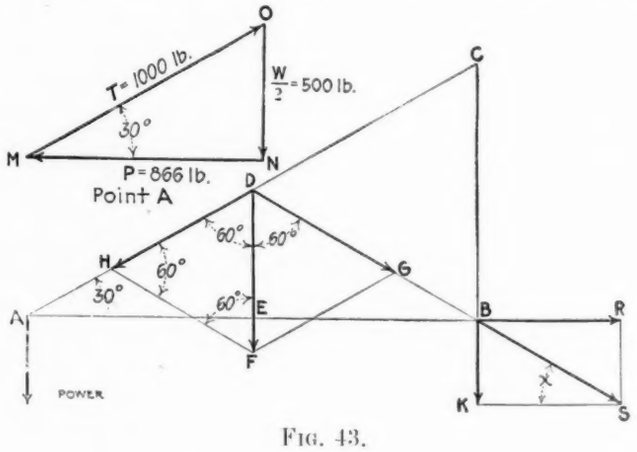



FIG. 43.

the reaction of the pin $B$, which is equal and opposite to the pressure $BS$, shown in Fig. 43.

49. There are four forces acting at the point $A$ (see Fig. 41, last week's lesson), namely, the weight of 4000 lb. acting downward, the pull of 3500 lb. in the hoisting cable $AC$, the unknown pull in the tie rope $AB$, and the unknown thrust in the boom $AD$. In Fig. 44, let $OG$ equal the weight of 4000 lb. and let $OH$ represent the pull of 3500 lb. in the hoisting cable; let $OR$ represent the direction of the resistance offered by the boom, and $OS$ the direction of the resistance of the rope. Under

the action of these four forces the point $A$ remains at rest and the forces are in equilibrium. Hence the direction and magnitude of the forces may be represented by the sides of a polygon taken in order. Now construct a force polygon by drawing the line $OG$ vertical and making it equal 4000 lb. to an assumed scale; from the point $G$ draw the line $GK$ parallel to the force $OH$ (which is

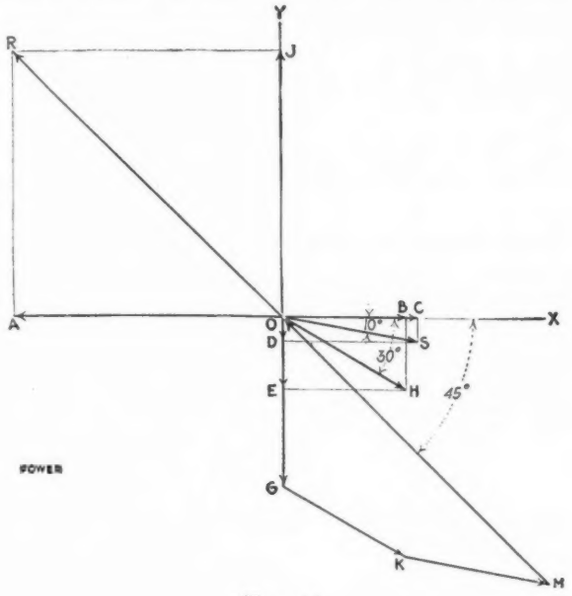



FIG. 44.

the tension in the hoisting cable) and equal to 3500 lb. to the same scale as $OG$; from the point $K$ draw the line $KM$ parallel to the force $OS$ (which is the unknown pull in the tie rope). Now extend the line $RO$ until it intersects the line $KM$ at the point $M$. The line $MO$ is then the closing line of the polygon $OGKMO$ and gives the direction and magnitude of the resistance exerted by the boom to counteract the load acting upon it. By measurement the line $KM$ is found to equal 3350 lb. and the line $MO$ equals 8950 lb.

This problem may also be solved analytically by resolving all the forces into their horizontal and vertical components, as shown in Fig. 44. Thus $OC$ is the horizontal component, and $OD$ the vertical component of the force $OS$. Next apply the laws of equilibrium as stated in Lesson X, under Case III. The $\Sigma H$ and $\Sigma V$ must equal zero, thus,

$$\Sigma H = OS \cos 10 \text{ deg.} + OH \cos 30 \text{ deg.} - OR \cos 45 \text{ deg.} = 0$$

$$= 0.985\ OS + 0.866 \times 3500 - 0.707\ OR = 0$$

or

$$0.707\ OR = 0.985\ OS + 3031$$

and

$$\Sigma V = 0$$

$$\Sigma V = OR \sin 45 \text{ deg.} - OS \sin 10 \text{ deg.} - OH \sin 30 \text{ deg.} - W = 0$$

or

$$\Sigma V = 0.707\ OR - 0.174\ OS - 0.5 \times 3500 - 4000 = 0$$

or

$$0.707\ OR = 0.174\ OS + 5750$$

Hence

$$0.985\ OS + 3031 = 0.174\ OS + 5750$$

or

$$0.811\ OS = 2720$$

and

$$OS = 3353 \text{ lb.}$$

Substituting this value of $OS$ in the equation above and solving for $OR$ there results,

$$0.707\ OR = 0.174 \times 3353 + 5750 = 6334$$

or

$$OR = 8957 \text{ lb.}$$

Therefore the pressure on the boom is 8957 lb.

50. The value of the pull in the rope was found to be 3353 lb.

By this time, if the student has carefully followed the text and the solution of the various problems given from week to week, he should be able to apply the principles studied to the solution of many problems that constantly face him in power-plant work. Lack of space forbids the solution of all the classes of problems that might arise.

The next few lessons will take up some of the applications of Statics to the simple machines, such as levers, balances, pulleys, etc.

As a final help to the student the following four rules are given for the solution of any and all problems either in Elementary Mechanics or any other subject.

I. *Think.*
II. *Analyze.*
III. *Equate.*
IV. *Solve.*

STUDY QUESTIONS

No advance study questions will be assigned this week, but as a substitute the student is urged to review the problems of the previous weeks, and to master any points which he has failed to grasp.

## Beating the Central Station

BY E. O. HAMILL

Some time ago the writer accepted a position as engineer in a manufacturing plant which was operating its machinery with induction motors and purchasing current from the city light and power company. There were 10 motors in the factory, ranging in capacity from 1 to 50 hp., and, as might be expected, the light and power bills were exceedingly high. I was satisfied that the power could be produced much cheaper than the company was buying it, but in attempting to induce the company to install its own power plant it became evident that not one of the management was familiar with engineering subjects and all were averse to spending money for a new plant.

The establishment was a woodworking factory, and to dry the lumber and heat the building in winter it was necessary to install a boiler. This had been done, and as the factory had only been built for about three years the boiler was still in good condition. It was of the fire-tube type rated at 150 hp. and built for 125 lb. steam pressure. This gave ample capacity, and it only remained to get an engine and generator.

Formerly the company had been located in a near-by town and at that time had a plant of its own, but due to the poor service obtained from the engine it was left behind when the change was made to the new location. An investigation showed that this engine had been well preserved and would require very little fixing to put it in good running order. A report on this matter was finally

presented to the directors, who decided to let me have the engine.

About 75 per cent. of the power was consumed in the milling department, which was all in one room, the machines being operated by three motors, one 50 hp. and two 35 hp. each, belted to a line shaft which ran the full length of the room. As the engine had a center crank, I decided to run a belt from one side to the line shaft in the milling room, and a belt from the other side to a small generator for furnishing current for the lights and small motors in other departments of the factory. The engine was of the balanced slide-valve throttling type, and in the old factory had been operated at 150 r.p.m. After rebabbitting the main bearings the eccentric strap and the crosshead shoes, planing the valve and its seat, turning up the piston rod and putting in a new valve stem, I equipped the engine with a good oiling system and placed it on a substantial concrete foundation. I then speeded it up to 200 r.p.m., ran it for two hours, and then put on the load. It has run without a hitch ever since.

The next thing was to obtain a generator. The engine was already operating the machinery in the milling department, so that there was no further use for the three large motors. By a piece of luck I succeeded, after some correspondence, in getting a second-hand, 40-kw., alternating-current generator complete with exciter, switchboard and instruments, in exchange for the three motors. The generator was as good as new and had only been used a few days. It had been purchased by a contractor who, in placing the order, had specified the wrong voltage, and the owners were unable to use it. The generator was wound for 230 volts, so that it was not necessary to use a transformer. The motors operated on 220 volts, and the lights on 110 volts. By using a balance coil on the lighting circuit I was able to install a generating set at very small expense.

Instead of live steam the exhaust was used for heating, and the steam pipes, which formerly had been bare, were covered. Last winter the plant was operated on less fuel than it required in previous winters for heat alone. No extra help to care for the plant was needed as the company had always employed a licensed engineer. The saving is apparent. The company has simply obtained its power free, which means from $250 to $300 per month, as this is what the bill was when purchasing current from the lighting company.

During the summer months when no heat is required in the factory the plant can be operated on 1800 lb. of coal per day of 10 hr. if coal alone is used. At times, however, the refuse from the woodworking department is almost sufficient to keep the boiler in fuel. The coal costs $2.15 per ton delivered. The total cost of installing the plant, including labor, all of the material for the foundation, belts and other equipment, was a fraction over $400. The company saved this amount in two months' time.

**Side-Pusher Electric Locomotives** are used on the Cleveland ore docks of the Pennsylvania R.R. They do not run on the same tracks as the cars they move, but on parallel 42-in. gage tracks at one side. Each carries a triangular side-arm frame on trunnions and this is raised to clear or lowered to engage the corner or pole plates. Energy is taken from two protected rails lying inside the running rails.

## OVER THE SPILLWAY

### JUST JESTS, JABS, JOSHES AND JUMBLES

Great combustibles! Is the fireman coming to his own? On page 794 you'll find out just what such engineers as Captain Manning, George Diman, I. E. Moultrop and F. W. Dean think of the importance of the efficient boiler-room force. Exciding, the fireman rides in the first hack and the engineer is tagging on the rear of the procession.

A kind publisher sent us an advance review on "Complex Hyperbolic and Circular Functions"—but neglected to send the book. We would like to believe every word he says about this entertaining and sprightly little book, but we dassent print the review. Nobody can put one over on us until we first get a squint at the complexity of his hyperbole. No, sirree!

"Passionsfestspielpenkrauterklostterdelicatessenstuckskaese" is the name of a new cheese. This may be all right for a new cheese, but just suppose some grease maker took it into his poll to wish such a name on his product. Oh, limburger!

A certain Connecticut town, intending to increase its water supply, will "build a watershed covering about 50 acres." One of the town officials, a building contractor, who naturally favored the "shed," has been severely criticised by a fellow townsman thusly (or pretty nearly thusly): "'Twill be a 'tarnation shame, by heck, ef Ezekiel Billin's gits ther job of puttin' a shed over fifty acres of water! I'm agin it, tooth an' nail. Zeke's got sufficient outen ther town already!"

A Chicago man named Hellmuller didn't like his name, for some reason or other. It's a perfectly good name, but it was too hot and too long for Hans. The court told him he could cut the "hell" out of it, and the chopping began that minute. Hope that the Himmelreiches won't follow suit, won't be anything left out there but Chicago—and there are folks who don't believe in an intermediate state.

Nine hundred and twenty-five feet of "Aquitania" will soon bump into our shore. She's really 901 ft. over all, but the evident patriotism of her British owners has tacked a 24-ft. lion on her prow, thus making her longer than the "Imperator." The latter lost her eagle in a recent storm. Looks like the open season for eagles and lions, so here's how to 'em both!

Dear Billy Spills: Does anyone besides myself, when by myself, get "beside himself"?

C. O'TWO.

Sometimes, I'm beside myself,
And the other self is Me—
Me and I can't seem to glimpse
All things as they should be.

Me sometimes agrees with I,
Then I thinks the same as Me.
Now and then, it is the case
That we both will disagree.

I and Me should get together—
Dwell in gentle amity.
Me's the best friend that I've got,
I should think a heap of Me!

Every now and once in a while some G. Washington Wellwisher manifests his kindly interest in "Power" by sending us a clipping or a suggestion, but he does not sign his name. "Power" wants to thank brother Wellwisher by letter, at least. Don't be so 'tarnation modest. You make us feel that we can't pay our debts.

Here's a case in point of anonymity: "C. O. S." writes that the English "smoke-abatement bill makes it incumbent upon the owner, OCCUPANT or user of a furnace to have it consume its own smoke. It seems to me that the composition of the 'occupant' of a furnace has much to do with the smokelessness. Some 'volatile' individual would probably cause the furnace to emit much smoke, but 'fuel' like me (and composed principally of carbon, capped with ivory) would smoke but little, or not at all."

# Inquiries of General Interest

**Best Time for Blowing Off Boiler**—What is the best time for blowing off a mill boiler?

C. H.

In the morning before the fire has been started up, as much of the sediment in the boiler will then have settled to the bottom of the shell and will pass out when the blowoff cock is opened.

**Ventilated Fire-door Frames**—Why are boiler fire-door frames sometimes made with holes extending through the frames, all around the fire-door openings?

D. E.

The holes are intended to serve as passages for air for cooling the dead plate, jambs and arches of the fire-doors and for supplying the air thus warmed to the top of the fire.

**White Lead vs. Graphite for Pipe Thread Joints**—For making screw-threaded steam-pipe joints, is it better to use white lead and linseed oil or graphite mixed with cylinder oil?

J. W. D.

For steam joints a "dope" of graphite and oil is preferable to white lead and oil, more especially because joints made up with graphite can be drawn up with less friction, and when required, can be unscrewed easier.

**Sloping Bottom of Combustion Chamber**—What is the advantage of filling and sloping the floor of the combustion chamber behind the bridge-wall in a return-tubular boiler setting?

E. D. G.

The principal advantage is in affording greater convenience for cleaning the combustion chamber by drawing the soot down the sloped floor to the cleaning doors.

**Size of Neutral Lead**—In a three-wire direct-current system why is the neutral lead often made the same size as the outside leads?

L. F. B.

The neutral is generally made the same size as the outside leads to comply with the National Electric code, which permits a fuse to be dispensed with if the neutral wire is of the same size as the outside wires and the neutral is grounded. The objection to the use of a fuse in the neutral lead is that if the fuse should blow when the load is unbalanced, the side of the system carrying the smaller load will be subjected to excessive voltage, which might be great enough to blow out the lamps.

**Inches of Vacuum for 1 lb. Absolute**—How many inches of vacuum are equivalent to 1 lb. per sq.in., absolute pressure?

J. W. S.

Taken at ordinary temperatures about 2.04 in. of mercury column is equivalent to a pressure of 1 lb. per sq.in. As "inches of vacuum" signifies the amount which a pressure is less than atmospheric pressure expressed in inches of mercury, then for any particular case the inches of vacuum equivalent to 1 lb. per sq.in. absolute would be the height of the barometer in inches, less 2.04 in.; for instance with a barometer reading of 29.2 in., a pressure of 1 lb. per sq.in. absolute would be equivalent to

$$29.2 - 2.04 = 27.16 \text{ "inches of vacuum."}$$

**Loss of Power from Slipping of Belt**—When there is slipping of a belt on a driving pulley, how is it explained that the per cent. in loss of power is the same as the per cent. of belt slipping?

J. F.

In belt transmission the number of foot-pounds per minute delivered to the driving pulley equals the peripheral speed in feet per minute multiplied by the net resistance of the belt in pounds, taken as the difference between the tension of the tight and the slack side of the belt; while the number of foot-pounds of useful work which the pulley transmits to the belt equals the velocity of the belt in feet per minute multiplied by the number of pounds of difference in tension of the tight and the slack side of the belt. Hence when slipping exists the useful work transmitted to the belt will be less than the useful work applied to the driving pulley by the same percentage that the velocity of the belt is less than the useful work applied to the driving pulley by the same percentage that the velocity of the belt is less than the peripheral velocity of the pulley or "percentage of slip," and this difference in energy is lost as it is employed solely in overcoming the friction which is incident to the slipping of the belt.

**Natural Gas Compared with Coal**—How many feet of natural gas would be required to obtain the same heat as from one ton of coal?

S. W. R.

The average natural gas has a calorific value of about 900 B.t.u. per cu.ft. and good grades of coal have an average calorific value of about 14,000 B.t.u. per lb. Therefore the complete combustion of one ton or 2000 lb. of coal would yield

$$14{,}000 \times 2000 = 28{,}000{,}000 \text{ B.t.u.}$$

so that with equal perfection of combustion about

$$\frac{28{,}000{,}000}{900} = 31{,}111 \text{ cu.ft.}$$

of average natural gas would be required for obtaining the same heat as from one ton of coal.

**Safe Pressure for Boiler Joint**—What would be the safe boiler pressure per square inch, as based on the longitudinal joint with a shell 78 in. in diameter, the thickness of the plates being ¾ in., their tensile strength 55,000 lb. per sq.in. of cross-section and the efficiency of the joint 89.8 per cent. of the solid plate?

M. W. C.

The strength of the solid plate being 55,000 lb. per sq.in. of cross-sectional area then the strength of the joint for 1 in. of its length would be

$$1 \times \tfrac{3}{4} \times 55{,}000 \times 89.8 \text{ per cent.} = 37{,}042.5 \text{ lb.,}$$

and allowing a factor of safety of 5, the joint would have a safe working strength of

$$\frac{37{,}042.5}{5} = 7208.5 \text{ lb. per in.}$$

of its length. The diameter of the shell being 78 in., the resistance required across 1 in. of length of the joint would be equivalent to the boiler pressure per square inch exerted on

$$\frac{1 \times 78}{2} = 39 \text{ sq.in.,}$$

and the joint would, therefore be suitable for a working pressure of $7208.5 \div 39 = 184.8$ lb. per sq.in.

**Allowable Working Pressure on Stay-Bolt**—What would be the maximum allowable boiler pressure per square inch for 1⅛-in. diameter screwed stay-bolts having riveted-over ends and pitched 4¾x4½ in.?

W. M.

The outside diameter of the stay-bolts being 1⅛ in. = 1.125 in., then with 12 V-threads per inch their diameter at the bottom of the thread would be

$$1.125 - (\tfrac{1}{12} \times 1.732),$$

or

$$1.125 - 0.1443 = 0.9807 \text{ in.,}$$

and the net cross-sectional area at the bottom of the thread would be

$$0.9807 \times 0.9807 \times 0.7854 = 0.755 \text{ sq.in.}$$

Allowing 6500 lb. per sq.in. of cross-section, the allowable load per stay-bolt would be

$$6500 \times 0.755 = 4907.5 \text{ lb.}$$

As the cross-sectional area of the stay-bolt at the bottom of the thread is 0.755 sq.in., and the pitch of staybolts is 4¾ × 4½ in., then the net area supported by a stay-bolt would be

$$(4\tfrac{3}{4} \times 4\tfrac{1}{2}) - 0.755 = 20.62 \text{ sq.in.,}$$

and the allowable pressure would be

$$4907.5 \div 20.62 = 238. \text{ lb. per sq.in.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for inquiries to receive attention.—EDITOR.]

# Boiler-Room Practice

The last meeting of the Engineers' Club of Boston was devoted to the above subject, a discussion of which was introduced by the following paper by Captain Charles H. Manning, of Manchester, N. H.:

I have been invited by our Committee on Meetings to talk this evening on "Boiler Room Practice," presumably of the present day or the uptodate practices, and to arrive at that point I purpose to go back to my first experiences and sketch at random some of the changes that have developed in my more than fifty years of life among boilers and fire rooms.

Late in 1861, the breaking out of the civil war having prematurely ended my course in engineering at the Lawrence Scientific School, I started in to learn the trade of machinist at Charles Reeders' Engineering Works at Baltimore, my native city.

## A POWER PLANT IN THE SIXTIES

My first job, as the last new apprentice, was to run the power plant of the establishment, which plant consisted of a locomotive boiler of about seventy horsepower located in a "leanto" being as naked as it came from the boiler shop; and an engine that it was hard to find because enveloped in a cloud of steam from leaky joints and stuffing boxes, that located it, and that was all. One of my chief duties was to wheel sufficient coal from a frozen pile some hundred or more feet away and out of doors, to keep up steam from seven a.m., till 6 p.m. That first fireroom job gave me a respect and consideration for a coal heaver that few of you have.

The boiler seams were of the lap single-riveted type, no butt straps, leave alone the "sawtooth" double-butt-strap of today. There was no double pop safety valve but a single, old-fashioned lever valve with a lever long enough to hang a spare shovel on to increase the pressure in time of stress. The blow and check valve chambers were made onto the boiler with cast-iron borings and sal ammoniac driven joints. There was no water gage, but three gage cocks, which I well remember, as the joker of the shop opened one of them down the back of my neck, much to my discomfort and to his sorrow.

## THE FIRST SHEET OF ASBESTOS PACKING

There was no automatic damper, steam flow meter, superheater, economizer, fan blower, induced draught blower, automatic stoker, $CO_2$ recorder, automatic feed regulator, feed water heater; except that the engine exhausted into an open tank from which the feed was supplied. The hand-hole and manhole joints were four-strand plaited gaskets, for though sheet rubber had come into limited use at that time it was too expensive for this purpose and it was not till a year later that I handled the first sheet of asbestos packing that was ever made. There was no steam flue cleaner but the old-fashioned rod with alternate iron and leather washers. There was, as may be inferred from what I have before stated, no automatic stoker fed from an overhead coal bin with automatic weighing apparatus in the down spout, nor ash conveyor. There was, however, a steam gage which if vigorously rapped would jump up or down if the pressure had varied since it was last rapped. The engine had no automatic cutoff and its speed was regulated by the throttle and steam pressure, and there was no forced-feed oiler but a good squirt can.

Now I do not claim that this was an uptodate plant at that time, but it was the power plant of a shop that built marine beam engines up to cylinders of 90-inch diameter and 12 feet stroke which, with the moderate pressure in use, gave about 500 hp. Contrast some of these things with the "boiler room practice" of today and, of course, that practice is much controlled by what we have to practice with. Where shell boilers are to be used the nature of the longitudinal seams is the first thing to be considered. It goes without saying that they must be double-butt-strapped seams, but shall they be triple or quadruple riveted with the inside strap broader than the outside or shall they be sawtoothed straps of the same width? I fail to find any mention of the latter in the preliminary report of our Committee on Boilers, notwithstanding the support it has received from eminent authority within the society.

Whether the power boiler is to become a thing of the past, to be succeeded by the internal-combustion engine, which is fast coming into its own, is a conundrum I will leave for our younger members to find the answer to.

In the boiler room today we find hot surfaces covered with some nonconducting material, and the question between the many is whether the more expensive ones save enough over the cheaper grades to pay interest and sinking fund expenses; and there are many other holes in this skimmer, on both sides of it. Hair felt is the best as it has the largest percentage of air spaces, and that is what counts; true while it lasts, but its life is very short. I have found a good quality of asbestos cement, not mud, the most profitable in my experience. Pop safety valves we find in all modern plants, and their design has been a matter of much refinement, but from the nature of the service reliability is the first quality to consider, and this means simplicity of construction, and the twin valve, much used in the marine service, with one locked so that it cannot be monkeyed with, will fill all the requirements of the uptodate plant.

We find today on all boilers a glass water gage and gage-cocks, and some engineers insist on a constant use of the gage-cocks which, as long as the water bobs up and down in the glass, is worse than useless, for you know the passages must be free; but when the water in the glass becomes suspiciously still is the time to resort to the gage cocks. This holds true even with the latest refinement of automatic feed valves, for, though their purpose is to carry a more constant water level, the action in the glass should be the same. The saving of fuel accomplished by this device is negligible, but in a large battery of boilers where water tenders are employed it can make reduction in labor expense.

The water level is the most important item in boiler room practice, and I have always been a believer in employing a water tender whose sole duty was to see that the water level is kept at proper point, and he the only man allowed to touch a feed or blow-off valve. This is "Safety First," which has always been the corner stone of my belief.

The steam flow meter, one of the latest innovations, giving information as to how much the boiler is doing at the instant is a very valuable guide to the engineer.

## A BAN ON THE HIGH CHIMNEY

In the matter of air supply for fires, we find either the direct blower or induced draught has largely superseded the immense and costly chimney with its heat-wasting propensity, and I think in the future we shall see very few chimneys built any higher than barely necessary to get rid of the products of combustion without offense. The capacity of a chimney being directly as its diameter and as the square root of its height, diameter is what we want, and where sufficient height cannot be allowed with the low temperature of escaping gases, resort should be had to exhaust fans, but better to an air-tight furnace with automatic stokers and blowers; for as soon as the pressure of the furnace gases exceeds that of the surrounding atmosphere, or becomes a plenum instead of a partial vacuum, we have burned-out furnace doors and a deadly atmosphere for the fireroom.

The correct draft arrangement is of the greatest importance to the designing engineer. Intimately connected with this in its operation is the $CO_2$ recorder or some other instrument of constant operation, that the operating engineer may know just what he is doing. To assist to this knowledge there should be syphons or other delicate pressure gages in the ashpit, the furnace and the flues. The practice of feeding boilers with any kind of water that comes handy—and if it disagrees with the boiler of giving the latter a dose of medicine to cure if possible—is rapidly disappearing, and the practice of giving the water the medicine first is progressing; it is the only right way to do. This practice, even to distilling every drop of makeup water that goes to the boiler when that is necessary, is bound to come.

## THE FEED WATER QUESTION

The weighing or measuring by weir all water fed to the boilers, as practiced in many plants today, is a move in the right direction, for though having no direct bearing on operating costs except to slightly increase them, it gives a knowledge of what is actually being done, and therefore is useful. The feed water heater question is one of the live ones today, and the economizer is one part of it. Some designers claim that with steam-driven auxiliaries, the exhaust steam of which will furnish all the heat required for the feed water,

it is better to omit the economizer and allow the gases to go off at a wasteful temperature of 500 deg. or over and so save in first cost of plant and care and upkeep of economizer, and that may be so, but I do not believe it. In the first place all the auxiliaries should be power driven, for it is certain that the power can be furnished at less cost from the main plant than it can be made in detail, and the lower the temperature of the escaping gases the higher the economy of the plant. Of course, there are modifying circumstances in every plant, and it is on these that the designer of the plant must use his brains.

With water-tube boilers the question of handhole gaskets has been solved by making ground joints, and better fittings and asbestos gaskets have solved most of the old-time sorrows on this point. Modern practice recognizes the importance of clean boilers inside and out, and for fire-tube boilers, both horizontal and vertical, the steam tube blower has been found very useful in cleaning the tubes daily or oftener instead of the older practice of once a week, and similar contrivances are in use with good effect on water-tube boilers. The internal scaling of water tubes and external scaling of fire tubes is another story, and a much more difficult problem, but the correct solution of it is to use water that makes no scale, purifying the water before it is fed to the boiler.

### A GANG OF "MONKEYS" TO CLEAN BOILERS

At Key West, during the late unpleasantness with Spain, there were lots of little yachts with all kinds of boilers, usually firetube boilers with the tubes bent in all directions. These boilers were so small that a good-sized man could not get into them, and we used a gang of "monkeys" (darky boys) to clean them out. This gang of little fellows, under the direction of one overseer, was the best boiler-cleaning outfit that I ever ran, and they were the source of the only labor trouble that we had. They struck for one penny more an hour—and we gave it to them.

The only objection I know of to ash conveyors is that they hide what I want to see the first thing in going into a fireroom, the furnace refuse, as it is always the source of the quickest information as to what is going on in the plant. The recording pressure gage is one of the best features of the modern plant, and where the records are kept on file, as they should be, you have a ready and valuable record of what has been done, and the most valuable part of the Log which should be kept in every station.

### HEIGHT OF THE FURNACE

Much has been written lately on the height of the furnace, with a very general tendency to increase this dimension, and for long flaming or highly bituminous coals this is right, but where anthracite is to be burned, especially with a boiler set in a brick casing, it is all wrong as it increases the opportunity for inleakage of air which is very destructive of economy.

The boiler plant for a textile mill to run fifty-eight or less hours a week must differ from that of an electric power company situated in a city where real estate is high. Coal pockets and automatic handling of coal; which in the latter case are a necessity, are generally costly luxuries in the former, as the fixed charges on the investment are going on all the time while its use is limited to a few hours a day. The practice today in the boiler room is to use a higher grade of labor and a stricter discipline, with closer supervision, till, from the old time go-as-you-please place that it was, it is now a place of military precision.

There is no doubt of the economy of a high rate of combustion, forcing boilers above their rating and using high superheat and a high vacuum, especially with the steam turbine in connection with the best surface condensers it is possible to purchase; and automatic stokers.

### PURCHASING COAL BY B.T.U. METHOD

On the purchase of coal by the B.t.u. method I am still a heretic where a large plant is concerned.

A highly bituminous coal will give a very high B.t.u. value. When that coal is fired by hand and a shovelful first strikes on top of the fire, the hydrogen flashes off and you lose three-quarters of the value of the hydrogen in the coal. The best test of coal for hand firing is the fixed carbon. The coal with the highest fixed carbon will do the most work on a common hand fire. With bituminous coal the automatic stoker will give a higher average result, because, the coal being shoved under the fire, the hydrogen is distilled off gradually and you get the value of it. The advantages in labor saving are immaterial, but you get a better result with a coal with hydrogen in it than you can get with the best hand fire. Test the best coals on the market in one of the regular boilers used in every-day work, and, other things being equal, the fuel that evaporates the most water for the dollars is pretty sure to be the most profitable to buy.

With steam turbines the better vacuum you get the better results and the last inch or two is the most important. It is impossible with a jet condenser to get as good a vacuum as you can with a surface on account of the air introduced with the water. This would make no difference with a reciprocating engine, but the turbine is like a multiple-cylinder engine with a low-pressure cylinder of almost infinite size.

### ECONOMY OF AUTOMATIC STOKERS

I once had a boiler-room foreman who was very much opposed to automatic stokers. I made him a proposition that he take a battery of ten boilers and run a 36-hour test on it, with the best firemen that he could pick. I would then run a test with the same kind of boilers, stoker fired for the same length of time, same coal, same weighing apparatus, same everything, but with stokers. The results of the trial were 15 per cent. in favor of the automatic stoker, with a net saving of about 10 per cent., after all the steam for operating fans, stokers, etc., had been charged against them.

### CORLISS' LIMIT FOR PRESSURE WAS SIXTY POUNDS

The greatest change in fifty years is in the pressure of the steam. The ordinary pressure for stationary engines was 30 to 40 lb. In 1882, when I went to work at Amoskeag, I started to put in a pair of 2000-horsepower engines, and the question of boiler pressure was one of the uppermost things in my mind. I wanted to go to 150 lb. Mr. Corliss, with whom I talked it over, had been putting the pressure on compound engines at 60 lb., and Mr. Corliss assured me that anything over 60 lb. was bound to get me into trouble and was of no use. Steam gages were not made without a special order to record over 100 lb., and I settled down to 100 lb. pressure, not because I thought it was enough, but it was all that I could get standard pipe fittings, gages, etc. for. During the time in question pressures have gone from an average of 40 to 200, which is about high enough, because the gain from increase in pressure is in a decreasing ratio, and the difficulties increase very fast.

W. G. DIMAN, Superintendent of Power, Amoskeag Manufacturing Co., Manchester, said:

Very little of the energy contained in the coal reaches the switchboard, and when this is taken into consideration it signifies that a great deal depends on proper combustion. The first requisite in combustion is to get out of the coal all of the heat that it contains, to use as much of the heat as is possible for the generation of steam and as little as possible for nonproductive purposes. Taking the price of coal at an average of $3 per ton, a week's run will show quite a loss or saving, due to the kind of firing. There is more to be gained or lost in a boiler room than in any other part of a power plant and for this reason the boiler plant should be placed in charge of a trained or a technical man. About 70 per cent. of the cost of operation of power plants is chargeable to boiler rooms, and for the handling of this expenditure the management often employs the lowest grade of labor instead of giving inducements to the intelligent workman to stay in the boiler room and handle this expenditure judiciously. While working toward better power-plant management and looking for more efficient engineers, the boiler room has somewhat been left to care for itself, and in many cases the labor has been entirely unfitted for the care and operation of the plant. The waste in the average boiler plant is great, and a good part of it is preventable. The idea appears to prevail that it takes brains to run an engine room while just brawn is sufficient for the boiler room. Even the worst turbine operator cannot greatly decrease the efficiency of the prime mover, while in the boiler room the loss in economy due to ignorance or lack of suitable indicating and recording apparatus will run high. There is, as a rule, in every boiler house a chance for improvement, and you can generally find evidences of the lack of knowledge on fuel economy. Preventable losses exist in nearly every power plant. The general practice is to burn coal and to keep up steam at any cost. An average man generally operates the boiler house, and average firemen, who know only generally the art of firing, burn the coal regardless of the economical results. It is not the general practice to educate men to burn coal to the best advantage. A man may be a good fireman from the standpoint of safety and reliability, he may keep his surroundings clean and always have the steam up, but this does not prove that he is getting the best results out of the fuel.

### COMBUSTION ENGINEERS FOR BOILER HOUSES

In time the practice will be to employ what may be termed combustion engineers to operate boiler houses and to gradually instruct the men under these engineers by constant supervision to become skilled in proper combustion work. It

is always best to employ as expert firemen as is possible, for economy is the result and there is just as much reason, if not more, to use this class of men for regular running conditions as there is to look for such men to run tests.

We blame the fireman many times when he does not know, expecting too much from this class of men. Generally the kind needed cannot be employed at the wages paid firemen. Firemen are entitled to some instructions, no two plants are alike and no two boilers act alike unless they are made to do so. The methods pursued in one plant are different from those in places where men were previously employed. The combustion of coal, the load, draft and furnace equipment call for a method that perhaps could not be followed in any other boiler room. You have a license law in this state. Some parts of the license law for the firemen may be good. I do not think, however, that one question is ever asked the fireman as to what he knows in regard to the proper combustion of fuel. Would it not be a benefit to the fireman as well as to his employer if he did know something of the running conditions inside the boiler as well as how to obtain the most economical results? In this manner he would be educating himself as well as being more valuable to his employer.

It is not a good plan to hold the fireman responsible until the foreman knows everything is all right himself, and this can best be obtained by recording instruments from daily running conditions. A fireman's duty is, as a rule, done when he maintains a level, even-burning fire of the correct height, regulates the draft to suit the load and fuel conditions, maintains a uniform water level and keeps soot out of the boiler. Finding air leaks, determining the proper height of fires and correct draft for load conditions is the combustion engineer's business. Firemen must use judgment, but fuel and load conditions in nearly every plant admit of finding what furnace adjustments are needed. Every fireman should understand that just as much fuel can be wasted by excess air coming through uneven and too thin fires as through an open furnace door. No one man can look at a boiler furnace and say exactly how near or how far it may be from its highest economy.

Steam boilers have been employed for 200 years, but less is generally known about them and their operation than the electrical engineer has found in 25 years about the practical forms of electricity. In the average boiler rooms the steam gage and water glass are about the only instruments that have been provided, or the only ones that have been paid any attention to by the firemen. No instruments showing the condition of the fires, the air supply, gases, etc., have been used to any great extent, and it is for this reason that so little is known by the average foreman and fireman. It is more important to consider as a part of the boiler equipment instruments that will show the water evaporated, coal burned, steam given out, and the furnace adjustments than to equip the prime movers with proper instruments, and more can be saved. With such instruments any local losses can be determined for elimination.

## IMPORTANCE OF INSTRUMENTS IN BOILER ROOM

To the ambitious fireman instruments are as important in the boiler room as the indicator is in the engine room, except that they have the added advantage of giving continuous indication of the process of combustion. Every fireman should know the meaning of the different instruments and what each means to him. As a rule, at present they mean nothing for the simple reason that he has never been educated to understand them. If he had he might become more interested and try for better results. With reliable instruments it is within the power of every fireman to intelligently procure proper combustion.

The interest of the men must be kept up and some standard set to which they must work. This can only be maintained by the man in charge either through some form of bonus or by showing the fireman that by firing correctly with the assistance of the proper instruments his work will be better, with less exertion on his part.

Recording instruments are preferable as they show the average existing daily conditions, and make all tests one of weekly or monthly running condition, which is the only fair test to run. All charts should be closely examined daily by the foreman in charge so that he may note any discrepancy and can hold the man under him responsible for economical results. The majority of plant owners are willing to purchase instruments provided the fireman can show that he is familiar with the subject of combustion and fuel economy and can convince the management that through their constant use a check can be kept on the average running conditions and money saved thereby.

One of the best instruments for showing the general working conditions on an individual boiler is the steam flow meter. While these meters may not be absolutely accurate, so long as they give relative indications, they are a great help. If the fireman sees that his arrow goes up under certain conditions he knows that he is getting better results, and if he is at all ambitious he will soon learn what conditions will keep the arrow at its highest point.

The foreman must know what results give the best working conditions and he must run the boilers as near their rating as possible. A comparison should frequently be made between the rated capacity of the boilers and the running conditions as they exist to show whether the boilers are over or underloaded to meet the condition of best economy. When the boilers are run far below their rating the loss increases greatly. Peak loads are carried better by running the boilers temporarily above rating. With the Manning type of boilers an efficiency of about 72½ per cent. or over is obtained with capacities from about 68½ to 123 per cent. of the normal rating and the efficiency falls off rapidly after passing 125 per cent. of the rating. When a constant load is carried, only enough boilers should be run to carry the load at their normal rating. In many cases more boilers are run than is necessary or they are run more above rating than will give satisfactory economical results.

## FEED-WATER AND DAMPER REGULATORS

Automatic devices are good so long as they remain automatic, but the more complicated you make any boiler and its appurtenances the more trouble you will have. Each device has its own merits, and each if given sufficient attention might prove satisfactory for a considerable length of time, but it is a question whether such devices would offset the operation of a boiler by a properly trained and educated fireman. There are many feed-water regulators on the market, some of which are satisfactory, but in a large plant where regular water tenders are employed the use of these regulators will lead to carelessness, and while they may work satisfactorily for a while, there may be a time when they will work disaster. Some of these regulators may give a steadier feed than hand regulation, but this must be offset by the safety element which such an automatic device cannot cover. In small plants where the fireman is the engineer, fireman, and general handy man a water regulator may be satisfactory, but in a large plant its use is questionable. There are balanced-draft devices on the market which give satisfactory results and border on meeting the ideal conditions of combustion, but such devices, like all others, mean constant vigilance. If the firemen are educated as they should be and we have trained men for the boiler house, then proper combustion can be obtained without the aid of automatic devices. Until this condition exists, boiler-room economy must suffer.

One important factor that is gradually coming into vogue is a signaling arrangement between the switchboard and the fire rooms. This is very important from an economical standpoint as the fire room must be kept informed of the load, any change in it or any anticipated change, so that the boilers may be properly run to cover the conditions. This is not always done.

## NEW ENGLAND MILLS FIFTY YEARS AGO

GEORGE H. DIMAN, Consulting Engineer of the American Woolen Co., and father of the preceding speaker, said:

The mills in New England 50 years ago were run as follows: The kind of boilers used were plain cylinder boilers, about 30 inches in diameter, 30 feet long, with three set in a battery; this made one furnace. The gases passed underneath the shell and then to the chimney. Hognose boilers; two 15-inch flues passed through the center of the boilers and the gases passed part way underneath the boiler, and then to the chimney.

Anthracite coal was used exclusively; the sizes were steamboat, grate and egg, no bituminous coal being used. Millions of tons of small-size anthracite lay in the valleys of the Pennsylvania coal regions which nobody thought could be used, nobody reasoned that there was just as much carbon in a pound of this coal as in the larger sizes. These have since been cleaned up and burned.

Seventy-two to eighty pounds steam pressure was the limit. The appliances on the boilers consisted of three gage cocks, a steam gage and weight and lever safety valves.

Boiler makers in each city and town in the state were allowed to build the boilers as they saw fit. No attention was paid to economy of the steam plant. All they looked for in those days was to keep the mill going. The water was supplied through an open heater, using a pump to take the water from the heater to the boilers. The supply of water to

the boilers was regulated to the supply into the heater, and many times through the carelessness of the fireman the heater was allowed to fill up, and the first thing they knew, the exhaust pipe was full and backing into the cylinder.

The engines were mostly Corliss beam engines, but just about that time they began to build horizontal engines. There was not an engine of over 1000 hp. running in New England. If there was a pair of engines, one cylinder was used condensing and the other noncondensing. All the piping was cast iron, and all the joints were put together with red lead putty. These were the conditions I found existing 50 years ago. The indicator was something unknown in mill practice, and I do not think that there was an indicator owned in a New England mill at that time. Mr. Frank Bacon, of Boston, did all the indicating.

About 1875 the mill men began to look for economy in the steam plants in New England, not paying any attention to the boiler room, and thinking all the saving was to be made in the engine room.

### A HORSEPOWER ON THREE POUNDS OF COAL

Here is where I received my first encouragement. The mill had twelve horizontal tubular boilers and a pair of 30-in. x 6-ft. Corliss engines. The agent of this mill encouraged me in every way, and so did the assistant superintendent, Mr. Walter H. Parker, now agent of the Pacific Mills. Still, we kept looking in the engine room for economy and utilizing the steam for manufacturing purposes. Here is where I assisted in making the first test of an engine. (I have the original letter with me this evening, and if any of the members wish to see it, they may do so.) Mr. Nathaniel Herreshoff, the famous yacht builder, was employed by Mr. Corliss as draftsman, and being a young man like myself at that time, and thinking it might please Mr. Corliss, we perhaps jockeyed the test a little. When I showed the report to Mr. Corliss (just to show you how honest he was in his dealings), he told me that when I went home I had better put that in a bureau drawer, and not show it to anyone; if his engines were producing a horsepower on 3 pounds of coal, he was satisfied. The reason he said this was that, taking a Midland steam report from England, the engines while being compounded were using from 10 to 14 lb. of coal per horsepower per hour. Of course, this was bogey coal—by bogey coal I mean the waste coal from the mines. Of course, you must remember that engines at that time in England were slide-valve engines, and the governor was in the steam pipe, which of course, wire-drew the steam.

### THE FIRST COMPOUND COTTON-MILL ENGINE

About 1880, the people where I was employed contemplated building a new mill, and having read a great deal about compounding, I was very anxious to have a pair of compound engines put in. Mr. Corliss was much opposed to this, and his excuse was, as I said before, that his engines were doing better than the mill engines of England. Mr. Henthorne was his head draftsman at that time, and being good friends with him we worked the matter together. Finally he consented to build a compound engine; and this was the first compound engine ever built for a cotton mill in this country. The guarantee was 1.67 lb. of coal per horsepower per hour, taking the steam out of the receivers to do the slashing. The engine fulfilled the contract.

Being much interested in the boiler room end, and satisfying myself that nothing more could be done to improve the engine, I turned my attention to developing a system of firing which would make a saving, and from that time to this I have devoted all my time to the boiler room end. I feel that this is the place where the chief engineer of a steam plant should spend his time. I am satisfied that he can make no saving on the engine end or on the turbine end of our steam plants today. All he can do here is to see that they are kept in good condition, properly lubricated, and a high vacuum obtained on the turbines. The saving must be made in the boiler room.

### HOW COAL WAS BURNED IN THE EIGHTIES

To show how ignorantly coal was burned in New England in 1883, I was called to take charge of a large steam plant—four woolen mills, and four cotton mills. There were six different boiler rooms in this plant, they were burning anthracite coal and all were small horizontal tubular boilers. Injectors were used to feed them; not a heater nor a pump on the place; they did have pumps, but they abandoned them as they thought it cost too much to keep them in repair. Fires were allowed to burn out every night. No matter what condition the fire was in, all the coal on the grates went out with the ashes and new fires were started in the morning. Pine cord wood at $4 per cord was drawn into the yard every day to start these fires. The ashes were not picked over, and many families in the town got their winter's supply of coal from them; the mill took particular pains to have the ashes hauled down to the dump early in the morning.

All these mills were heated with direct steam, and the overseers were allowed to go into the boiler rooms and turn on the valves when they saw fit. Nearly all the engines were Greene engines, about ten in number. They were given a general overhauling once a year, which consisted of reseating the valves by the use of a bastard file, a coldchisel and a hammer, and then grinding them in with emery and oil; when the job was finished the valves were in worse condition than before. I stopped all this, and had the valves scraped in, and we did not have any overhauling each year.

I want to call your attention particularly to one engine, of which I have a photograph. This engine was built to get over the patents of George H. Corliss. You will see it is a very peculiar engine. My attention was called to it when I arrived at the mills, and was told it was a very good engine because it had a very strong exhaust. I replaced the cylinder on this engine with a Corliss cylinder. They had great trouble in this mill with leaky tubes. Their system was to blow off the boilers every Saturday night and refill them immediately with cold water, keeping the boiler maker and helper busy retubing them. I called the boiler maker's attention to this, asking why he did not stop this system. He said he did not want to take the bread and butter out of his mouth. I told him to go to the office and get his bill. We stopped blowing off the boilers and refilling them while hot, and had no more trouble with leaky tubes.

### A 1200-FT. CONDENSING MAIN

We had two mills, one on each side of the river, 1200 ft. apart. Both engines were running noncondensing. No use for the exhaust steam. Having plenty of old pipe in the mill yard, I conceived the idea of connecting the engines and running condensing. The smart ones said it wouldn't work, but they were much disappointed. You can run an engine with the condenser a mile away, providing the piping is tight. All the difference it makes is that it will take a little longer time to get the air out of the pipe before you start. We had a Knowles condenser. After I had accomplished this, I went to Boston to the Blake Pump Co., which then controlled the Knowles pump, and wanted to buy a condenser to do what I had accomplished. They said they would not sell me a condenser. After showing them the cards from the engines, they were very much surprised and changed their opinion.

The first steam plant that I took charge of which I considered uptodate in every way for economy was designed by E. D. Leavitt, Mr. Dean, superintendent. This was in 1887. I will just say this about the engines. They were designed for 1200 hp., the most economical load to run, but, having a great deal of use for exhaust steam, we have loaded these engines from 2000 to 2400. The engines have run continuously since May 1887 with the same crankpin boxes, never having been rebabbitted. The boilers were horizontal tubular, 78 inches in diameter, tubes 18 ft. in length, 3 inches in diameter. Grate surface in boilers 56 sq.ft.

### SMOKELESS SYSTEM OF FIRING

This is the time I began to turn my attention to the boiler room end. I feel, and I know, that a system of firing can be established with most any kind of bituminous coal used in New England and have a smokeless chimney, but the boilers must be properly designed. I feel that you can get better results with small units with hand-firing than with any other system. In my observations of other systems, it will be impossible to get any kind of results unless the furnaces are manipulated by skilled help occasionally, to cover up the holes where the furnaces are fed automatically. I think that the horizontal tubular boiler, where there is plenty of room, is the best all-round boiler that can be used for manufacturing purposes.

Take the boilers that were designed by Mr. Leavitt, and started in May 1887. After having been run 18 years under a pressure of 140 lb. and driven away above capacity, the insurance company reduced the pressure to 120, so that we removed these boilers and placed them in other mills where lower pressure was required, and these boilers are running today without having been retubed.

I was once reprimanded about the care of these boilers, because I was using too many manhole gaskets, but I told my superior that manhole gaskets were a great deal cheaper than boiler makers.

### AUTOMATIC DRAFT VS. THE TALL CHIMNEY

I feel that you can get a great deal better results with an automatic draft—say, induced draft—than you can with

great tall chimneys, and it is possible to reduce the stack temperatures very low. I do not believe in tall chimneys. You are limited to the power of the chimney, and you have to carry a high temperature to get draft. For instance, take the stack temperature at the Wood Mills; it has never run above 220 deg., and the boilers are running between 50 and 100 per cent. over rating. With a chimney at that temperature, it would be impossible to get the power of the boilers regulated.

I believe in high furnace temperature, and having the boilers properly designed to absorb most of this heat. The boilers at the Wood Mills are 78 inches in diameter, tubes 20 feet long, 3 inches in diameter, with 2300 ft. of heating surface. With these boilers running 100 per cent. over rating at times, I have never seen the temperature leaving the boilers over 450 deg.

I feel that we cannot pay too much attention to feeding the boilers with water. If you will notice the operations of the steam flow meter attached to your boiler, and watch the fireman as he opens the feed valve carelessly, you will be astonished to see the horsepower drop. I have watched the operations of our boilers, and have had the fireman open the valve carelessly, and the boilers have dropped from 500 hp. to 300 hp. in less than thirty seconds. Just stop to think of the effect of pouring some water into a kettle of boiling water—it is just so with feeding the boiler carelessly.

## NEED FOR THE GOLDEN RULE

To obtain the best results in your boiler-room and engine-room force, you must have first a good feeling, and in order to have that good feeling, you must use the men under you as you would want to be used yourself. In my fifty years of experience, no matter in what mills I have been employed, I have never gone outside the mill yard to get help. I have always promoted the men in the mill. This gives the men an incentive to work for, and it makes a great deal better feeling. All of our chief engineers in our mills in Lawrence are young men who have grown up under me.

Another thing I am very careful about—perhaps it is foolish on my part—but I have never yet failed to introduce any who come to visit the plant to the man in charge. In fact, I always have the man show the company around the plant. We all like to be recognized.

Finally, I see a great many young men around me tonight, and I want to leave this parting word. Do the very best you can for yourself and your employer. No matter what discouragement you may meet with, keep on doing your best. If new appliances are put into your hands to use, and you do not feel favorably toward them, banish that thought from your mind and try to make them do better than they were intended to do.

I. E. MOULTROP, of the Edison Illuminating Co. of Boston, said that boiler units are going to increase in size. There was no use in putting in 20,000-, 30,000- and 40,000-kw. turbines and hitching them up to a line of little boilers. The reliability of the boiler is beyond question. At the Delray station in Detroit the reliability of the boilers is even greater than that of the turbines. By using a large boiler you get a greater amount of heating capacity within the same brick setting, and have less firebrick to heat up and cool down. There is less cracking to cause air leaks, and the investment is less. The investment item is the big item; the operating cost is secondary. The operating costs exist only while the plant is running, but the investment costs keep on all the time. The large boiler units take less space and less piping.

## NO HAND FIRING FOR LARGE CENTRAL STATIONS

Handfiring is out of the question. The stoker is going to be of the underfeed type. He did not mean to specify any stoker on the market, and would not want to recommend any that is in existence at the present time. The advantages are numerous. One of the principal advantages is that you can force boilers, by which he meant forcing them up beyond anything which has yet been done. One or two stations are running boilers to 250 and 350 per cent. of rating. His company did the same thing at the L Street Station. The Interborough people, in rebuilding the Seventh-fourth Street Station, New York City, contemplate running boilers at 450 per cent. of their rating, and he did not know as that was the limit. This also keeps down the investment and gets away with banking the fires. Few realize how much it costs to carry fires banked.

Another advantage is that you have positive control of your draft. The chimney for a big power plant will cease to be the draft-creating device. Its function will be to take the products of combustion far enough into the air so that the power plant will not be a nuisance to its neighbors. They had had occasions when the load on the station doubled in half an hour. It would be utterly impossible to meet such a condition with any form of boiler-room equipment that depended upon chimney draft.

The boiler room will be equipped with better devices for telling the fireman what is taking place. We give a fireman the most important job in the station, and give him nothing but a cracked pressure gage to tell him how well he is doing it. The steam flow meter is one of the most important devices with which any big power plant can be equipped. We need to know what the draft conditions are, and that they are constant.

Too many automatic devices are bad; the fewer, the better, but what you do have, be sure they are reliable.

## FIRE ROOM LABOR

The most important matter is that of fire room labor, and the operation of the fire room is the most important job in a power plant. The economy of the turbine room is in the hands of the constructing engineer. The fire room job has never been congenial. The man who has the intelligence and the ambition to do that sort of work would not tackle that sort of a job. Visitors admire the engine and turbine room, but they stick their heads into the fire room, and duck! Make the fire room just as agreeable a place for the men to work in as possible—neat, clean, well ventilated—and cut out the manual labor. When you make the fire-room job one which the man can run and keep himself as neat and clean as the man in the turbine room, you can get the right kind of men to run it. He did not believe in having the chief engineer sit in the office most of the time looking over charts. Let the clerk do that.

## BOILER PRACTICE ONE OF DESIGN

JAMES D. ANDREW, also of the Edison Illuminating Co., of Boston, said that undoubtedly boiler practice is one of design. The simpler the plant can be designed and the more rugged, the better will be the efficiency. In earlier times the belief was prevalent that everything had to be duplicated for safety. As years went on, and the expected failures did not occur, designers were giving up the duplication, with better results. The majority of operations should be made as nearly automatic as possible. The stoking should be automatic, the boiler feed, the combustion control. He did not feel that recorders were of much advantage; they dealt with ancient history. What was needed was indicators which would show what was going on at the time. He spoke of a combustion indicator designed by E. G. Bailey as both ingenious and clever. The back damper of a boiler is a good indicator of what is going out. The steam meter shows the amount of steam delivered. There should be a certain volume of gas delivered by the fire, and the back damper is a good measure of that gas. It is not a difficult matter to put an attachment from the back damper to the front of the boiler and calibrate that telltale so as to show just where the back damper ought to be for each output of the boiler.

After you have made the majority of the operations automatic, see to it that the fireman, instead of sitting down, is busy looking for holes in the fires, etc. Proper weighing apparatus should be provided for keeping track of the amount of coal being burned, and checking it against the electrical output. So far as the feed water is concerned, Capt. Manning is absolutely right. Evaporators for distilling water for the make-up should be provided; such evaporators use high-pressure steam for boiling the makeup water, and then pass the high temperature condensate back to the boiler. Make-up water is seldom over 15 or 20 per cent., and this can be easily provided.

## AIR SUPPLY

E. G. BAILEY, of the Fuel Testing Co., said that his hobby was air supply. It takes so much air to economically burn a pound of coal and the pound of coal properly burned will make so much steam; it is a question of relation between the air supply and the steam output. Automatic regulators are worse than useless. Draft recorders are more important than steam recorders. The rate of air supply, with a sensitive damper regulator, varies from 50 to 75 per cent. for a variation of 2 or 3 per cent. in the steam supply. The pressure goes up, and the damper will almost completely close, leaving the fire without a sufficient supply of air, until the pressure is dropped, when it will immediately fly wide open, admitting as much of an excess as there was a deficiency before.

The great problem of today is to supply air to the furnace in exact proportion to the demands for steam.

F. W. DEAN, consulting engineer, of Boston, contributed the following discussion:

It is now well established that the boiler room of a power plant should receive more attention than heretofore. Men of unusual skill and intelligence should be in this department, as here is where lie the greatest opportunities for economy. With recent means of indicating and recording all of the important features of boiler room performance, one can know constantly whether things are going on properly.

Many people do not realize what savings can be made by proper firing unless they have had within their experience cases where it has been shown. I remember one such experience in which the evaporation per pound of combustible from and at 212 deg. was increased from 8.34 lb. to 9.54 lb., and then to 12.84 lb. This was done by putting in a new grate, studying the case in various ways, but chiefly by improving the firing.

The days of reciprocating feed pumps seem to be numbered, and centrifugal steam or motor driven pumps are better in several ways. They give no trouble about packing, can pump hot water, make no pulsations, and render the action of feed water recording apparatus better. On the principle that the most economical steam engine is the simple non-condensing engine of which the exhaust can be utilized, it is best to drive feed pumps and other auxiliary apparatus by steam if the exhaust can be used for heating feed water or otherwise.

Concerning stokers it is my belief that they are indispensable in large public service stations with large overload requirements, but in moderate sized mill plants I do not think that they are advisable unless from conditions, overhead coal storage bins are advisable. In such cases if the plant is not too small a substantial saving in labor can be made because the coal can be delivered into the stoker hoppers through chutes. There is no economy of coal by the use of stokers if hand firing is properly done, for the best hand firing results have not been surpassed by the best stoker results. It should be mentioned, however, that a high grade of intelligence in boiler rooms is not as likely to be obtained, if men have to shovel coal, as would be the case if they directed coal to hoppers through chutes. The limitations of stoker and hand firing economy are of the same character, and they are either too much or too little air. It is easy in hand firing to keep a grate properly covered, but with some kinds of stokers it is not easy. It is here that the underfeed type of stoker has the advantage over other types, in my opinion. I should not forget that some stokers are smokeless and that all are more smokeless than hand firing is likely to be.

### LARGE BOILER UNITS AND ARTIFICIAL DRAFT

I am glad to see that the advantages of large boilers in large plants are at last being recognized. I have been advocating them for years, but it is difficult to influence mill men to use them. They cost less per horsepower, take up less room, reduce the cost of brickwork, reduce the size of the boiler house, reduce the number and cost of steam pipes, blow-off pipes, valves, general piping, pipe covering, etc., and finally the number of men required. In addition economy of fuel is promoted, for there are fewer losses from air leaks and radiation. There are no disadvantages, for any boiler is capable of working far above its rating, and therefore if a boiler is laid off the others can do the work.

Furthermore I am glad to see a final recognition of the advantages of artificial draft in large plants, and regarding the chimney as a device for carrying off smoke or invisible gases to a harmless height. A chimney for draft purposes is a relic of past times. Now that it is realized that boilers can be worked at heavy overloads, artificial draft enables this to be done. In central stations this reduces the investment enormously, and yet the peak loads can be carried without difficulty. I have long advocated artificial draft and have installed it several times, one installation being among the largest in New England. This, in connection with large boilers worked hard, has been one of my hobbies.

### ONE POWER HOUSE TO A TOWN

JOHN A. STEVENS, consulting engineer of Lowell, Mass., said that to install or not to install is a matter of finance, ground area, cost of buildings, coal in and out, ashes in and out, the cost of labor. How much does it cost over all? The fixed charges are villainous in factory plant work; 8 hours a day for the use of the plant and the fixed charges going on all the time. The tendency of the times is one power house in each city for the generation of power and simple heating plants, one power house, one engineer, and one oil can. In order to determine whether there was anything in feed-water regulators, they ran a 24-hour test, maintaining the water level constant, and another test of the same duration with the water line going up and down 12 inches. The difference in the results was negligible.

With regard to tall chimneys or forced draft, years ago Mr. Rockwood said, "Tall chimneys AND forced draft."

HENRY BARTLETT, of the Boston & Maine R.R., spoke of the automatic stoker as applied to locomotives. It was being applied, not because there appears to be any economy in its use, but because the engines are getting too large to be hand fired.

## Illinois N. A. S. E. State Convention

Hotel Jefferson, Peoria, was the headquarters for the tenth annual convention of the Illinois State Association, which was held on May 20 to 22 inclusive. It was the first of the numerous state conventions to be held this season and was up to the usual standard. Seventy-two engineers were registered, although only thirty-four were delegates, and with thirty firms exhibiting, the attendance must have reached 150. The local committees are to be congratulated on the results of their work. The exhibit hall was the Gold Room of the hotel which offered excellent facilities for the display of engineering specialties, and the meeting room adjoining was convenient and of the proper proportions to suit the attendance. The entertainment was of the variety for which Peoria is noted.

Wednesday was reserved for registration, the forming and renewal of acquaintances and an inspection of what the supply men had to offer. The convention was informally opened Thursday morning. W. G. Zierke, chairman of the arrangement committee, after a few words of welcome, called on Rev. B. G. Carpenter for the invocation. Mayor Woodward officially welcomed the engineers to Peoria and hoped that they would like it well enough to select it as a permanent convention city. He was impressed with the great motive back of the organization and it was his urgent request that they call on him for any services that the city could render.

In his response State President W. E. Hill spoke of the early days when it was the policy of engineers to hoard their knowledge of the engine room. With the formation of an association featured by educational work and an exchange of ideas, the times had greatly changed. The daily work and experiences are now freely discussed and as much help as possible is given one to the other.

John F. McGrath, past president of the national organization, waxed eloquent in an address touching on state license laws, industrial protection and compensation laws and a pension for the aged. The association wanted license laws, not because it is seeking positions for its members, but because it is looking for protection. A clean civil service administration is desired and let the best men take the places. The association is broad minded in every respect. Education is the watchword and every member is willing to stand his chance with any other engineer. Assistance will be given members to get work, but everything will be open and above board. He believed in home rule, but a state license law would not interfere. It was his hope that the Illinois association would have a healthy growth and be as large as any in the country. The members had a happy faculty of sticking together at the national conventions and were respected for it. It is the only way to accomplish results and the same spirit in local matters will make Illinois one of the greatest associations in the country.

Judge Stone impressed on the delegates the necessity for persistence in their efforts to obtain a state license law. It is a good quality and one that is needed to accomplish things worth while. It requires the best efforts of an individual or an organization to be a success in these days. Assistance is the keynote of every organization which has a purpose to carry out. It is needed individually and collectively, for no one can be independent.

In response to a request made by the chairman, Fred W. Raven gave the strongest talk of the morning. It had been nine years since the association met in Peoria and a notable improvement was evident, but he often wondered if all appreciated the fact that they were allowed to belong to an organization that is doing things. It was his opinion that the opportunities of the organization were only half realized by the members. It was a question whether the object of attending was a good time or to help each other. Frequently officers were selected at random. A careful choice was necessary, and if the association was to amount to anything the membership must take a great interest in its work. Education is open today and there is no reason why the members

should not be the biggest and brightest engineers in the country. The people of the organization and its possibilities received brief mention. The prospects in Milwaukee were bright for the biggest and best convention ever held. A united effort would insure such a result. Briefly, Mr. Raven reviewed the work of the association for the past year. Ten new locals had been added to the roster, the ladies' auxiliary was growing and the financial conditions were flourishing.

W. F. Raymond, of the local technical school, spoke briefly on the work of the engineer, and the more extended knowledge required in these days. Good books were needed and meeting places for pleasure and mutual instruction.

"Dad" Beckerleg brought back the days in the eighties, the first of the organization. It was due largely to its work that today there were better educated men, better dressed men and better engineers. His closing remarks touched on the pension fund and the life and accident insurance of the association.

A spirited contest between Peoria and Decatur adherents resulted in a choice of the latter for the next convention city. In choosing officers, President W. E. Hill, Secretary-treasurer Gus Anderson and State Deputy Henry Misostow were re-elected. E. R. Wortman was made vice-president. Installation of officers by "Dad" Beckerleg and short addresses by Charles Cullen, president, and C. H. Fiske, secretary and treasurer of the Central States Exhibitors association, closed the meeting.

The delegates adjourned to the exhibit hall and joined heartily in popular melodies until train time. Some stayed over to the smoker given that evening by the supplymen.

The firms exhibiting at the convention were as follows:

American Steam Gauge & Valve Co.
Anderson Co., V. D.
Armstrong Machine Co.
Carpenter Co., George B.
Chicago Pump Co.
Crandall Packing Co.
Kinsey & Mahler Co.
Liberty Boiler Cleaning Co.
Lunkenheimer Co.
McMaster-Carr Supply Co.
Meyer & Bro. Co., E.
Mueller Co., H.

DELEGATES AND GUESTS AT THE ILLINOIS N. A. S. E. STATE CONVENTION AT PEORIA, ILL.

President Hill then took the chair and shortly after the convention adjourned. The afternoon was spent sightseeing. The distilleries and the Avery Agricultural Implement Co. were visited, and in the evening a theater party was the feature.

Two sessions were held on Friday and all was business. Reports of officers and committees were presented. The report of the educational committee was enthusiastically received and the license committee was highly commended for its good work. In another year a state license law is expected. To make the constitution consistent and to incorporate the changes that had been made from time to time, a committee on revision had been appointed. The revised sections were read and passed upon, the principal changes relating to the arms of the association, the time of holding and announcing the state convention and representation from the different locals. The smaller associations were given more delegates so that they would not be so greatly outnumbered by the Chicago contingency. One delegate for every 25 members was allowed and no association was to have less than three delegates.

Couch & Heyle
Dearborn Chemical Co.
Garlock Packing Co.
Greene, Tweed & Co.
Hawkeye Compound Co.
Home Rubber Co.
Indian Refining Co.
Jenkins Bros.
Johns-Manville Co., H. W.
Keystone Lubricating Co.
"National Engineer"
National Refining Co.
Peerless Rubber Co.
Peoria Belting & Rubber Co.
Perolin Co. of America
Powell Co., William
"Power"
Thayer & Lynn
White Star Refining Co.

## Storage Dams on the Colorado River

Investigations of dam sites on the Colorado River made by private companies indicate that, in addition to the land now served by canals, more than 1,250,000 acres additional could be brought under irrigation by constructing storage dams on the upper Colorado and its tributaries. About 1,000,000 acres would be served by gravity distribution systems, while about 300,000 acres would require pumping plants to put water in the canals, the lift, however, being nowhere in excess of 80 feet.

The sum of $50,000 which was appropriated in March for the use of the Reclamation Service in investigating storage units and irrigation systems which might be developed on this river is expected to result in a favorable report on a storage capacity at several points totaling between 6,000,000 and 7,000,000 acre-ft. A site on the San Juan River, another at Kremling on Grand River, and a third in northwestern Colorado on Green River, all tributary to the Colorado, have been examined. Of these the last named is by far the largest, and is located in what is known as Ladore Cañon. Here the river banks are such that a dam more than 100 ft. high can be built which will have a water-level length of 500 ft. and yet will be only between 700 and 800 ft. long on the crest. The storage available is placed at 3,000,000 acre-ft.

These several storage units would be independent of the canal systems and would be used only to store water for regulating the stream flow. The probable points of diversion would be at Needles, Parker and Laguna, and would serve lands in the Yuma and Imperial valleys. These dams would make it possible, in the opinion of Louis C. Hill, the Government consulting engineer, who supplied the foregoing information, to irrigate considerable tracts of land in Mexican territory, although the acreage mentioned is wholly within the United States.

## NEW PUBLICATIONS

HOW TO BUILD UP FURNACE EFFICIENCY. By Joseph W. Hays. Published by Joseph W. Hays, Rogers Park, Chicago, 1914. Size 7¼x5 in.; 126 pages. Price, $1

The purpose of this book is to tell in a simple and interesting way why fuel losses prevail in boiler furnace operation; where to look for and measure these losses, and how to maintain economy when it has been obtained. The text is in the nature of conversation by the author with the engineer and the manager. Much of it relates to Mr. Hays' experiences in many plants where he acted in a professional capacity as a combustion engineer.

The little book treats the subject in a manner easily understandable to the average power-plant engineer and such men should, therefore, greatly appreciate its contents.

ENGINEERS' COSTS AND ECONOMICAL WORKSHOP PRODUCTION. By Dempster Smith and Philip C. N. Pickworth. Two hundred and forty-three 5½x8½-in. pages; 32 illustrations; 20 tables; numerous specimen forms; cloth bound. Price, 4s. 6d. ($1.12) Emmot & Co., Ltd., Manchester, England.

The interesting and useful contents of this book are not indicated by the title. It is a combined handbook of machine-shop practice and a reference book on the cost of machine building materials. Combined with this are chapters devoted to shop system and organization.

The book deals with the costs of material, including pig iron, wrought iron and steel, and copper alloys; tables which include the price of castings in specific districts of England; prices for steel- and copper-finished products, as bars, sheets tubes, castings, and the like. Specifications for materials include the standard tests established by the British Engineering Standards Committee; wage systems, shop organization and management, which are very similar to the treatment given these same subjects in this country; various methods of wage payment and shop systems are explained.

The book also deals with machine-shop practice and the inspection of work and kinds of fits.

The balance is devoted to the bookkeeping end of shop accounting, taking up the methods of applying the expense burden, a discussion of selling expense, a chapter devoted to railway rates, with tables of these rates for British conditions. This is followed by a chapter on the shipping of goods, relating more particularly to the matter of receipts, bills of lading, custom specifications, insurance, etc., the general features of cost keeping, and estimating.

Much interesting and valuable matter is contained in this work; but the specific references are to British conditions and methods.

GEAR CUTTING IN THEORY AND PRACTICE. By Joseph G. Horner; 391 5½x8½-in. pages; 367 illustrations. Indexed. Cloth bound. Price, 7s. 6d. ($1.80). Emmott & Co., Ltd., Manchester, England.

The author in his preface states as his reason for having prepared this book that "Many books have been written on the subject of gears, dealing with the design of teeth and giving some account of the shop practice connected with the formation of the tooth shapes. But none that I know of covers all of the later developments in a reasonably comprehensive manner. Either theory is treated apart from practice, or the work of the shops is dealt with in a too summary fashion." To overcome these difficulties has been his aim; portions of the matter have been previously published as articles in the "Mechanical World."

However, the reviewer fails to be favorably impressed by the result. The first 108 pages, comprising eight chapters, are devoted to a general discussion of tooth proportions and design followed by an analysis of the various methods of cutting. The matter is largely descriptive and contains far too little information to be of final service to the designer. The balance of the book, 257 pages, is devoted to descriptions of commercial gear-cutting machines, with notes on gear-cutting practice. This again, while interesting, seems to be of but little service to anyone except a student.

In view of the excellent works on gear design and gear-cutting practice, already in print, this work hardly seems to add material value to the literature of gear cutting.

## BOOKS RECEIVED

HEAT. By E. M. Shealy. McGraw-Hill Book Co., New York. Cloth; 262 pages, 6x9¼ in.; 110 illustrations. Price, $2.

McANDREW'S FLOATING SCHOOL. By Captain C. A. McAllister. International Marine Engineering, New York. Cloth; 256 pages, including 21 pages of tables for marine engineers; 6x8¾ in.; illustrated. Price, $2.

## ENGINEERING AFFAIRS

**Cincinnati Joint Meeting**—The joint meeting on June 4 of the Engineers' Club, of Cincinnati and the Cincinnati Section of the American Society of Mechanical Engineers will be addressed by a representative of the National Tube Co. on the subject, "The Manufacture of Steel Tubes." The address will be illustrated with motion pictures. The meeting will be held at eight o'clock p.m., in the auditorium, McMicken Hall, University of Cincinnati. This will be "ladies night," and the last meeting of the club until fall.

**Summer Courses at University of Wisconsin**—Announcement is made of the fourteenth annual six weeks' summer school of the College of Engineering of the University of Wisconsin, which opens on June 22. Courses of instruction and laboratory practice are offered in electrical, hydraulic, steam and gas engineering, mechanical drawing, applied mechanics, testing of materials, machine design, shopwork and surveying, in addition to which subjects may be taken in the College of Letters and Science.

**The Annual Dinner of the New York Chapter** of the American Society of Heating and Ventilating Engineers was held on the evening of May 18 at Reisenweber's Beef Steak Garret, 57th St. and Eighth Ave., about 125 members and guests attending. Informal addresses were delivered by Walter S. Timmons, the recently elected president of the chapter, and also by several other members, congratulating the chapter on the work done during the past year and bespeaking higher public appreciation of the profession of heating and ventilating engineering.

## OBITUARY

### GEORGE MILLARD

George Millard, of Burlington, Ia., secretary of the Citizens Water Co. and for many years connected with the Murray Iron Works Co., died May 4 at the age of forty-five years. Mr. Millard left a widow.

### M. CARELS

The death of Mr. Carels was announced at Ghent on April 27. Mr. Carels was one of the founders of the firm of Carels Frères, and the uncle of Messrs. Charles, Georges and Gaston Carels, who are now conducting the business. The deceased was born in Ghent in February, 1839. He was director of the Hospices Civils of his native town, chairman of the board of directors of the Hauts-Fourneaux et Laminoirs de la Sambre, and Officer of the Order of Leopold and of the Legion of Honor.

# Classified Advertising

**Positions Wanted, 3 cents a word, minimum charge 50 cents an insertion, payable in advance.**

**Positions Open, Employment Agencies (Labor Bureaus), Business Opportunities, Wanted (Agents and Salesmen—Contract Work). For Sale, 5 cents a word, minimum charge, $1.00 an insertion.**

**Miscellaneous (Educational—Books) 10 cents a word, minimum charge $1.50 an insertion.**

**Count three words for keyed address care of New York; four for Chicago. Abbreviated words or symbols count as full words.**

**Copy should reach us not later than 10 A. M. Tuesday for ensuing week's issue. Answers addressed to our care, 505 Pearl St., New York or 1144 Monadnock Block, Chicago will be forwarded (excepting circulars or similar literature).**

**No information given by us regarding keyed advertiser's name or address.**

**Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.**

**Advertisements calling for bids, $3.60 an inch per insertion.**

## POSITIONS OPEN

WANTED FOR PANAMA CANAL, experienced erectors for the erection of lock machinery; salary, $140 month; free transportation from New York or New Orleans; must be American citizens (final papers), under 45 years, in sound physical condition. Write Panama Canal Office, Washington, D. C.

## POSITIONS WANTED

TECHNICAL GRADUATE in mechanical engineering desires position as apprentice with concern manufacturing power-plant apparatus; location New York City or vicinity. P. W. 236, Power.

CHIEF ENGINEER-MASTER MECHANIC, large experience, good mechanic and executive, water-works, refrigeration, office building and factory experience; young, married and sober. P. W. 234, Power.

STEAM AND ELECTRICAL ENGINEER is open for position; experienced; technical education; first-class license; civil service; reference; West or Middle West preferred. Address "Engineer," Convent of Holy Names, Oswego, Ore.

MECHANICAL ENGINEER, unmarried, 26, Stevens graduate, good experience in power plant, experimental and executive work, possesses initiative, unusual mathematical ability, desires change; will go anywhere. P. W. 230, Power.

SUPERINTENDENT of power of large group of power plants, desires to correspond with employers requiring the services of a high-grade power-plant engineer; thoroughly experienced in all branches, and can deliver results; only a strictly high-grade position, and salary commensurate with same is solicited. P. W. 214, Power.

SUPERINTENDENT of stations or chief engineer; 10 years' experience central-power station, erecting and operating steam turbines and engines, high-tension transmission lines; first-class Ohio license; at present employed as superintendent of power stations; best of references. P. W. 235, Power.

ENGINEER, technical graduate, 10 years' experience with large engines, Curtis, Parson and Rateau turbines, up to date on electrical and refrigerating machinery, formerly chief engineer in large hotel, would like to correspond with a firm where exceptional ability and low-power production is appreciated; can furnish first-class references from past and present employer. P. W. 228, Power.

## WANTED

WANTED—100 to 250 H. S. fuel-oil engine, De La Vergne F. H. type preferred; must be in good condition and cheap for cash; state age, make, send number and lowest cash price, also when same may be seen. W. 231, Power.

### AGENTS AND SALESMEN

SALESMAN—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. W. 120, Power, Chicago.

MR. ENGINEER—If you are tired of the daily rut of your job and are ambitious to make a way for yourself in the selling end of the engineering line, we have something unusual to offer you; become a sales engineer and earn three to six times as much as your present salary; you can do it without any risk whatsoever, but you must possess certain qualifications; write us and we will tell you if you are eligible. We manufacture boiler appliances of the highest merit and standing, selling as high as $400 per boiler, and yielding in commissions as high as $100 per boiler; one sale may mean more than your week's salary; write us. W. 229, Power, Chicago.

## MISCELLANEOUS

PATENTS. C. L. Parker, patent attorney, 904 G St., Washington, D. C. Inventor's handbook sent upon request.

ENGINEERS—Do you want to utilize your exhaust steam for heating or drying purposes without back pressure on your engine? If so address Monash Engineering Co., 1417 West Jackson Blvd., Chicago, Ill.

CARR VENTILATED FURNACE ARCH gives 100 to 400 per cent. longer service than ordinary types; for nominal fee I will furnish plans with license to use, or will take pay in percentage of saving made. Elmer E. Carr, 411 Hartford Bldg., Chicago.

## FOR SALE

ATLAS ENGINE—One 11-in. by 16-in., automatic cutoff, in fair condition; may be seen in operation. F. S. 233, Power.

BUCKEYE ENGINE—One 13-in. by 21-in., automatic cutoff, in good condition; may be seen in operation. F. S. 232, Power.

BOILERS—Two 50-hp., 54-in. by 12-ft. return-tubular boilers, in excellent condition; will sell for $200 each f.o.b. cars Lockport, N. Y. F. S. 218, Power.

ENGINES—Five rebuilt 40- to 50-hp. Straight-Line, one rebuilt 75- to 85-hp. Straight-Line engine; all modern machines. Straight-Line Engine Co., Syracuse, N. Y.

CORLISS ENGINE—16x36 Hewes & Phillips Corliss, with wheel 12'x19", perfect condition, overhauled, $550. Duzets & Son, Hudson Terminal, New York.

ALTERNATOR—100-kw. G. E. type "ATB," rev. fld. 3 ph. 60 cyc. 240 volt alternator with exciter and switchboard, $550. Also 17x24 Erie City 4-valve engine, $750. Duzets & Son, Hudson Terminal, New York.

OIL ENGINES—32-hp. De La Vergne oil engine, perfect condition (cost $1900), $750; also 30-hp. Meitz & Weiss oil engine (cost $1500), $550. Duzets & Son, Hudson Terminal, New York.

TURBINE GENERATING SET—300-kw. Westinghouse Parsons three-phase, 60-cycle, 220- or 440-volt turbine outfit, with condenser; practically new. George Sachsenmaier & Co., 143 North Third St., Philadelphia, Penn.

COCHRANE HEATER—One No. 3, rebuilt and in excellent condition, $95; one American steel plate blower, three-quarter housing, bottom horizontal discharge, 24-in. inlet, first-class shape, $65. The Arbuckle-Ryan Co., 224-34 Cherry St., Toledo, Ohio.

BOILERS at Wilmington, N. C.—Battery of three 125-hp. horizontal tubular; insured 125 lb.; stack, 66 in. diameter, 90 ft. high, and breeching; manufactured by the E. Keeler Co.; cost, $3500 f.o.b. cars; will sell at bargain. McKenzie Mfg. Co., 765 North Ave., Plainfield, New Jersey.

FOR SALE AT BARGAIN, after July 1, one Armington & Sims cross-compound engine, 150 hp., 11½ and 18 by 15; write us for price or make us an offer. Memphis Electric Light, Heat & Power Co., Memphis, Mo.

PATENTS, PATTERNS, etc., for the simplest device for prevention of smoke on the market; this device is in successful operation; will sell outright, or on royalty basis; this device can be sold for less money and at a good profit than any other device on the market. F. S. 217, Power.

INDICATORS AND GOVERNORS FOR SALE—Steam-engine indicators, standard make, at $25 each; 4-in. Class "A" Pickering governors, at $20 each; 4½-in. Class "A" Pickering governors, at $25 each. All of the above material is in fine condition; full information upon request. Address Lyons Atlas Co., Indianapolis, Ind.

## CONTRACTS TO BE LET

**Bids received until June 10, 1914.**

### Heating Apparatus, etc.

Supervising Architect's Office, University of Illinois, Urbana, Illinois.—Sealed proposals for furnishing and installing all materials as per drawings and specifications for heating apparatus and auxiliaries for Armory, will be received at this office until 2 P.M., June 10, 1914. Information on application.

JAMES M. WHITE,
Supervising Architect.